

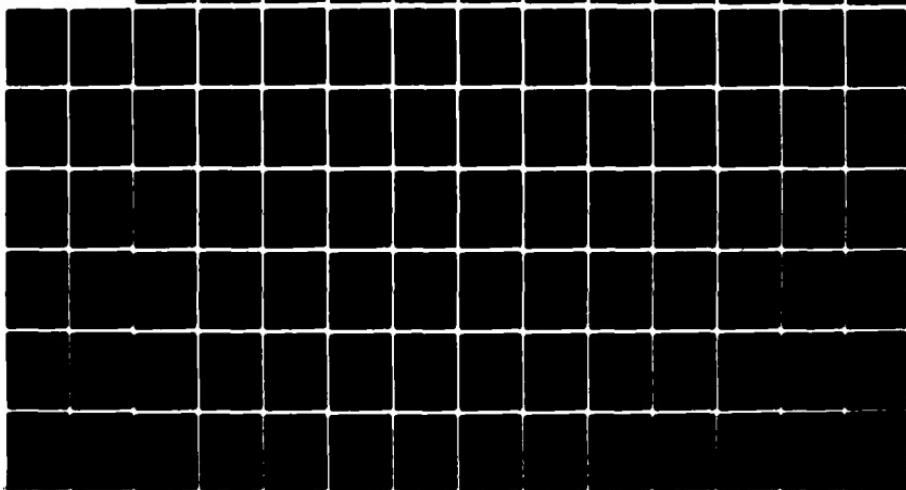
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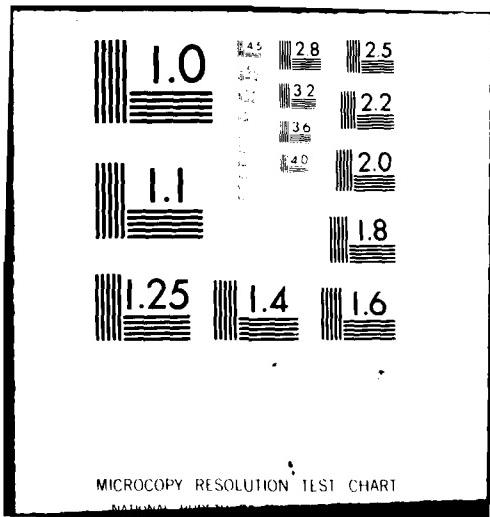
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MAKPH-452(81)

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HEADQUARTERS

OGDEN AIR LOGISTICS CENTER

UNITED STATES AIR FORCE

HILL AIR FORCE BASE, UTAH 84056

(6) SURVEILLANCE REPORT.

STAGE I  
DISSECTED MOTORS.  
PHASE XII.

PROPELLANT AND COMPONENT TESTING.

(5) PROPELLANT ANALYSIS LABORATORY

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MMWRM PROJECT M82934C

SURVEILLANCE REPORT

STAGE I DISSECTED MOTORS

PHASE XII PROPELLANT & COMPONENT TESTING

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January 1981

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## ABSTRACT

Testing was performed to determine the useful shelf/service life for LGM-30 Stage I Rocket Motors. A three year storage program for propellant and components was started in May 1961. This program was then extended to a ten year study and later continued indefinitely to assure that a deterioration in motor physical characteristics could be detected in time to take some corrective actions before the weapon system performance deteriorated below an acceptable level.

This report covers only propellant data and limited case bond data. The malfunction of an environmental chamber destroyed component samples that had originally been part of this testing program (and the inadvertent burning of some motors during dissection reduced the material available for testing). Planned dissection of selected motors in the future will provide samples for continued component testing. Test specimens for this reporting period were obtained from motors STM-012, 0012099, and 0012199. UP-7775 block propellant was not tested since that propellant has been used up.

A new technique of Multi-symbol Regression Analysis was used to determine aging trends. Also, using a unique plotting code for each motor tested demonstrates the relationship between motors and block propellant. The plotting symbols for each motor and block propellant are listed in the statistical analyses section.

The data from this test period was combined with data from previous testing and entered into the GO85 computer for storage, analysis, and regression analysis. From the statistical analysis of all data tested to date, significant degradation of the propellant does not appear likely for at least two years past the oldest data point.

Furture testing will be conducted on dissected motors.

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## GLOSSARY OF TERMS AND ABBREVIATIONS

Aging Trend	A change in properties or performance resulting from aging of material or component
CSA	Cross Sectional Area
DB	Dogbone
Degradation	Gradual deterioration of properties or performance
E	Modulus (psi), defined as stress divided by strain along the initial linear portion of the curve.
EB	End Bonded
EGL	Effective Gage Length
em	Strain at maximum stress
er	Strain at rupture
"F" ratio	The ratio of the variance accounted for by the regression function to the random unexplained variance. The regression function having the most significant "F" ratio is used for plotting data. The ratio is also used in detecting significant changes in random variation between succeeding time points
JANNAF	Joint Army, Navy, NASA, Air Force Committee
MAKPH	Propellant Lab Section at Ogden Air Logistics Center
Ogden ALC	Ogden Air Logistics Center, Air Force Logistics Command
r or R	The Correlation Coefficient is a measure of the degree of closeness of the linear relationship between two variables
Regression Equation	The general form of the regression equation is $Y = a + bx$
Regression Line	Line representing mean test values with respect to time
S <sub>b</sub>	Standard error of estimate of the regression coefficient

#### GLOSSARY OF TERMS AND ABBREVIATIONS (cont)

$S_e$ or $S_{Y.X}$	Standard deviation of the data about the regression line
$S_m$	Maximum Stress
$S_r$	Stress at rupture
Standard Deviation ( $S_y$ )	Square root of variance
Strain Rate	Crosshead speed divided by the EGL
"t" test	A statistical test used to detect significant differences between a measured parameter and an expected value of the parameter (determines if regression slope differs from zero at the 95% confidence level)
Variance	The sum of squares of deviations of the test results from the mean of the series after division by one less than the total number of test results
3 Sigma Band	The area between the upper and lower 3 sigma limit. It can be expected that 99.73% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed.
90-90 Band	It can be stated with 90% confidence that 90% of the inventory represented by the test samples would fall within this range assuming that the population is normally distributed

## INTRODUCTION

### A. PURPOSE:

This report contains test data from samples of LGM-30 Stage I, Wings I-V TP-H1011 propellant and case bond specimens. Testing was performed by the Propellant Laboratory Section (MAKPH) for the Engineering and Reliability Branch of the Airmunitions Management Division (MMWRBM) under Project M82934C-WNL17514. This report is the twelfth in this series. Data from this test period and propellant test data from the eleven previous reports were entered into the G085 computer for regression analysis. The regressions are shown in this report.

### B. TEST PROGRAM:

The LGM-30 Laboratory and Component Program includes the testing of materials used in the main case and main grain propellant. This report covers TP-H1011 propellant and case bond specimens. Table I outlines the test program.

Propellant for testing was obtained from three dissected motors; STM-012, a motor prepared by Thiokol specifically for dissection; S/N 0012099, a SLIM motor and S/N 0012199 which was selected for dissection. UP-7775 block propellant which had been tested during previous test periods was not tested at this test period as it was used up during the last test period.

### C. HISTORICAL BACKGROUND:

In May 1961, Thiokol began a three year LGM-30 laboratory storage and test program to determine the rate of degradation with age for Stage I materials. During June 1962 and again in August 1963, additional samples were included. New samples were added in July and August 1964 when the

surveillance testing program was extended to ten years (Test Plan 0717-62-0967, 53-8). Carton block propellant, batch UP-7775, containing TP-H1011 propellant cast in March 1962 was added to the program in 1964.

Samples added to the inventory in 1964 were considered to be a new population, but were combined in regression analysis with the three dissected motors. The history of testing of these materials is found in MQQP Report Nrs. 109A(67), 144(68), 208(71), and MANCP Report 358(76). Physical transfer of the specimens from Thiokol to Ogden ALC was made in June 1967.

TABLE I  
TEST PROGRAM

All Temperatures in Fahrenheit  
Motors STM-012, S/N 0012099, S/N 0012199

(Block Propellant UP-7775 was included in this portion  
of the test program in previous test periods)

<u>Test</u>	<u>Conditions</u>	<u>Spec/Cond</u>	<u>Spec Config</u>
Tensile	77°, 2.0 & 20 in/min	5 ea	JANNAF Dogbone
Creep	77°, 10 & 12 lb load	3 ea	JANNAF Dogbone
Stress Relax	77°, 3 & 5% strains	3 ea	1/2" x 1/2" x 4"
Strain Dilatation	77°, .25 in/ in/min	3 ea	1/2" x 1/2" x 4"
Hardness	77°, initial & 10 seconds	5 ea	Dogbone Ends
HOE	77°	3 ea	1/2" x 3/8" x 1"
Burning Rate	77°, 500 & 1000 psi	5 ea	.156" x .156" x 5"
DTA	77° start	3 ea	0.040" wafer
Ignitability	77°, 168 cal/ cm² - sec	3 ea	0.050" wafer
Sol Gel	77°	6 ea	1/2" x 1/2" x 1/2"

UP-7775 was NOT included in this portion of the test program  
in previous test periods.

High Rate Tensile	77°, 1000 in/in/min	5 ea	3/4" GL Dogbone
High Rate Triaxial Ten	77°, 1000 in/in/ min, 600 psi	3 ea	3/4" GL Rail
Dynamic Response	77°, 70 gm ct. wt.	3 ea	3.3" x 3.3" x 0.690" disc
Biaxial Constant Strain	77°	3 ea	3/4" GL Rail

TABLE I (cont)

<u>Test</u>	<u>Conditions</u>	<u>Spec/Cond</u>	<u>Spec Config</u>
Failure Envelope	Temp: -50°, -20°, 10°, 40°, 77°, 130° & 180°F at a rate of 0.2, 2.0 & 20 in/min	3 ea	JANNAF Dogbone

STM-012 and S/N 0012199 only were used for the following tests:

Case Bond Tensile	77°, 0.2 in/min	10 ea	1" x 5/8" x 3/4"
Tear Energy	77°F ± 2°	8 ea	0.1" x 1.18" x 3"
Poisson's Ratio (Strain Dilation)	77°F ± 2° 10, 15, 20, 25, 30%	6 per/ condition	0.50" x 0.50" x 4"

## STATISTICAL ANALYSIS

The objective of this statistical analysis was to determine whether or not any aging trends are demonstrated by accumulated test data in order to assist Service Engineering to more accurately predict motor serviceability.

Propellant was made available for testing and statistical analysis was performed on the resultant data in order to obtain an overall view of the aging trends affecting the First Stage Dissected Motor Program. The sampling consisted of data from two dissected operational motors (0012099 and 0012199), and one motor (STM-012) which was prepared by Thiokol specifically for the dissection program. In addition, carton propellant data (batch UP-7775) which was tested previously was included in the regression analyses.

A new technique of Multi-symbol Regression Alanysis Program was used to determine aging trends. The sampling is combined for each test parameter in a single regression analysis. The linear equation ( $Y = a + bX$ ) was found to be the best fit model for the data in this report. A composite population aging trend line is then calculated accepting the fact that individual aging of different populations may be masked.

The Multi-symbol Program uses a unique plotting code for each motor and carton data on the regression plots. This method of data plotting allows a visual display of the overall relationship between the various origins of data and how they relate to the overall least square aging trend line.

The regression program uses an analysis with individual data points from different time periods combined to establish a least square aging trend line for the overall data. The variance about the regression line, obtained using individual values of the dependent variable, was used to compute a tolerance interval such that at the 90% confidence level 90% of the population falls within this interval. This tolerance interval was

extrapolated to a maximum of 24 months to give an indication of the statistical significance of the slope of any aging trends. The computer tolerance interval about the composite regression line is wider than what the tolerance interval would be about any individual motor or carton regression line because of the increased data spread introduced by combining different populations of data. The "t" values and the significance of this statistic, which are reported for each regression model, gives an indication of the "statistical significance" of the slope of the aging trend in the Y-axis. Data and regression trend lines were plotted utilizing an IBM-360/65 computer.

#### ORIGIN SYMBOL TABLE

<u>Origin</u>	<u>DOM</u>	<u>Wing</u>	<u>Symbol</u>
Motor 0012099	63166	2	0
Motor 0012199	63227	2	1
Motor STM-012	61221	1	S
* Carton UP-7775	62075	1	U

\* The last of carton UP-7775 block propellant was used up on the previous testing period. No new data for UP-7775 will appear in this report.

## TEST RESULTS

Regression analysis is the method of evaluation used in the analysis of the test results.

### A. TENSILE:

Low rate tensile test data at 2.0 in/min shows a statistically significant gradual decreasing slope for strain at maximum stress and strain at rupture. Maximum stress and stress at rupture do not show a significant slope. The modulii show a statistically significant increase slope (Figures 1 thru 5).

The 20 in/min low rate tensile test data shows a statistically significant decreasing slope for the strain at maximum stress, strain at rupture and stress at rupture. Maximum stress and modulus do not show a significant slope direction (Figures 6 thru 10).

No significant slope direction is shown for the high rate regressions (Figures 11 thru 15).

High rate triaxial testing shows a statistically significant increasing slope direction for the strains with the stresses showing no significant slope direction. Modulus shows a statistically significant decrease slope direction (Figures 16 thru 20).

Case bond tensile data shows a statistically significant decreasing slope (Figure 21). For this test period 10 specimens from STM-012 and 4 specimens from 0012199 were tested. The failure mode for all STM-012 specimens was 100% adhesive, liner to propellant, and for 0012199 the failure mode was 100% adhesive, liner to propellant for three specimens and for one specimen 50% adhesive, liner to propellant and 50% adhesive, case to liner.

B. CREEP:

For the 10 and 12 pound load test the regressions show a statistically significant decreasing slope (Figures 22 thru 29).

C. STRESS RELAXATION:

Stress relaxation modulus for both 3% and 5% strain shows no significant slope direction except for 5% strain at 10 seconds which shows a statistically significant increase (Figures 30 thru 37).

D. CONSTANT STRAIN:

A statistically significant decreasing slope is shown for constant strain (Figure 38).

E. SHORE HARDNESS:

The Shore A ten second hardness shows no significant slope (Figure 39).

F. DYNAMIC RESPONSE:

The loss tangent regression for 200 and 400 Hz show a non-significant slope trend. The storage shear modulus at 200 and 400 Hz shows a statically significant decreasing slope (Figures 40 thru 43).

G. TEAR ENERGY:

No significant slope is seen for tear energy (Figure 44).

H. SOL GEL:

The percent extractables and weight swell ratio shows no significant slope (Figures 45 and 46). Sol gel, density and crosslink density show a statistically significant decreasing slope (Figures 47 and 48).

I. BURNING RATE:

A statistically significant decreasing slope is shown for both the 500 and 1000 psi testing (Figures 49 and 50),

J. HEAT OF EXPLOSING (HOE):

The HOE regression shows statistically increasing lsope (Figure 51).

K. DIFFERENTIAL THERMAL ANALYSIS (DTA):

The endotherm does not show a significant slope direction (Figure 52).  
The exotherm shows a statistically significant decreasing slope and  
the ignition temperature shows a statistically significant increasing  
slope (Figures 53 and 54).

## CONCLUSIONS

The test results show that, under present storage conditions, some of the physical/mechanical and combustion properties of the propellant indicate statistically significant aging trends. On some regressions where a significant trend is indicated, the slope of the trend line is quite gradual and no operational problems are expected. On other regressions, i.e., triaxial tensile and burning rate, the slope of the trend line appears quite steep although, in reality, the percent change is minor as indicated by the formulas found at the top of each figure. The Y-axis range is automatically varied by the data spread to provide visibility between individual data means. As a result, the range values (on Y-axis) must be considered when visually analyzing regression slopes.

Although some aging trends have been observed, it does not appear that any significant degradation will occur in the propellant within the next two years.

#### RECOMMENDATIONS

It is recommended that continued testing be conducted on the three dissected motors presently being tested and also on those motors selected for future dissection and testing by Service Engineering. On those motors selected for future dissection, testing should include the propellant, casebond specimens, and component materials.

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
54.0	26	159.0	24
73.0	24	160.0	5
75.0	2	166.0	5
82.0	5	167.0	5
87.0	5	168.0	16
94.0	16	175.0	8
97.0	7	176.0	3
104.0	5	177.0	5
106.0	5	179.0	8
108.0	5	180.0	3
116.0	5	191.0	12
116.0	5	200.0	3
123.0	4	201.0	3
130.0	5	203.0	5
133.0	15	205.0	3
135.0	2	215.0	6
140.0	5	226.0	3
144.0			
145.0			
146.0			
149.0			
150.0	10		
152.0	2		
153.0	5		
157.0	3		

STAGE 1 DISSECTED MOTORS LOW RATE CHS=2.0 IN/MIN. STRAIN MAX STRESS

This sample size summary is applicable to figures 1 thru 4

$F = +1.8247085E+01$  SIGNIFICANCE OF F = SIGNIFICANT  
 $R = -2.4173946E-01$  SIGNIFICANCE OF R = SIGNIFICANT  
 $I = +4.2716607E+00$  SIGNIFICANCE OF I = SIGNIFICANT  
 $N = 296$  DEGREES OF FREEDOM = 294  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

Y = (( +2.4405581E-01 ) + ( -1.2129311E-04 ) \* X)

$\sigma_f = +2.3242658E-02$

$S_f = +2.8394837E-05$

$S_e = +2.2591632E-02$

PARAMETER = STRAIN RT MAX STRESS

UNIT OF MEASURE = IN/IN

0.12

0.08

0.04

0.00

0.00

0.04

0.08

0.12

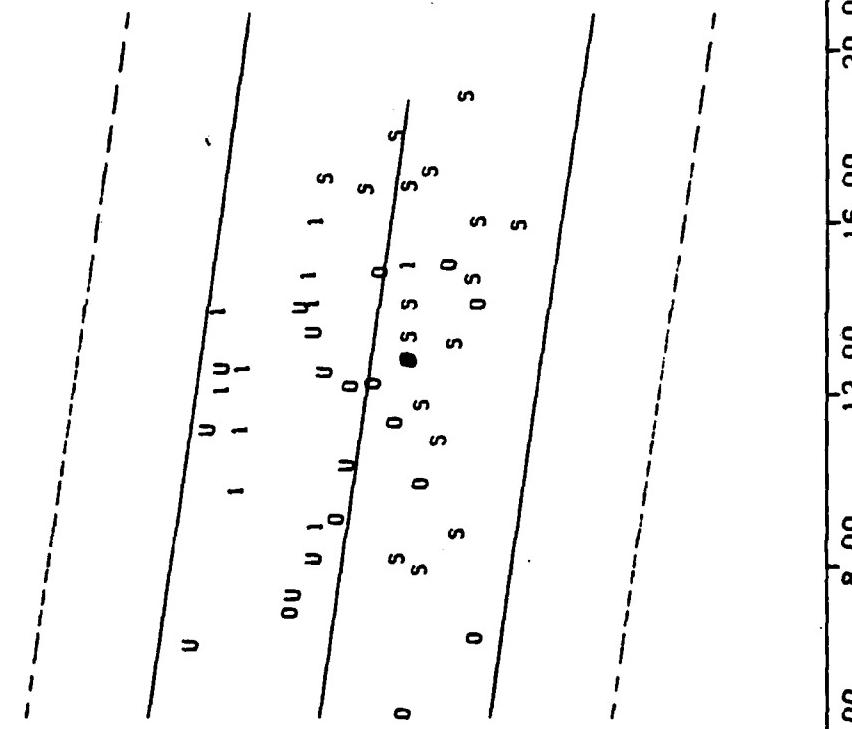
0.16

0.20

0.24

0.28

0.32

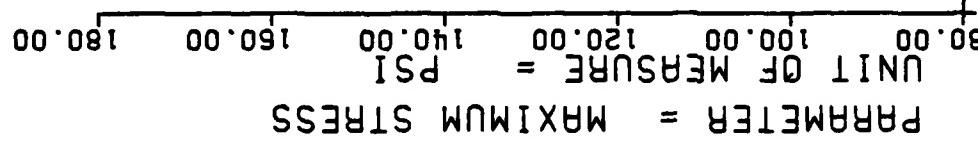


STAGE 1 DISSECTED MOTORS, LOW RATE CHS=2.0 IN/MIN, STRAIN MAX STRESS

Figure 1

$F = +6.8876461E-01$        $\gamma = (( +1.1626123E+02 ) + ( +9.8575414E-03 ) * X)$   
 $R = +4.8345229E-02$       SIGNIFICANCE OF F = NOT SIGNIFICANT       $G_f = +9.4452229E+00$   
 $I = +6.2991843E-01$       SIGNIFICANCE OF R = NOT SIGNIFICANT       $S_f = +1.1877723E-02$   
 $N = 296$       SIGNIFICANCE OF I = NOT SIGNIFICANT       $S_r = +9.4502093E+00$   
DEGREES OF FREEDOM = 294      TEST CONDITIONS = AMB TEMP/RH

STORAGE CONDITIONS = AMB TEMP/RH



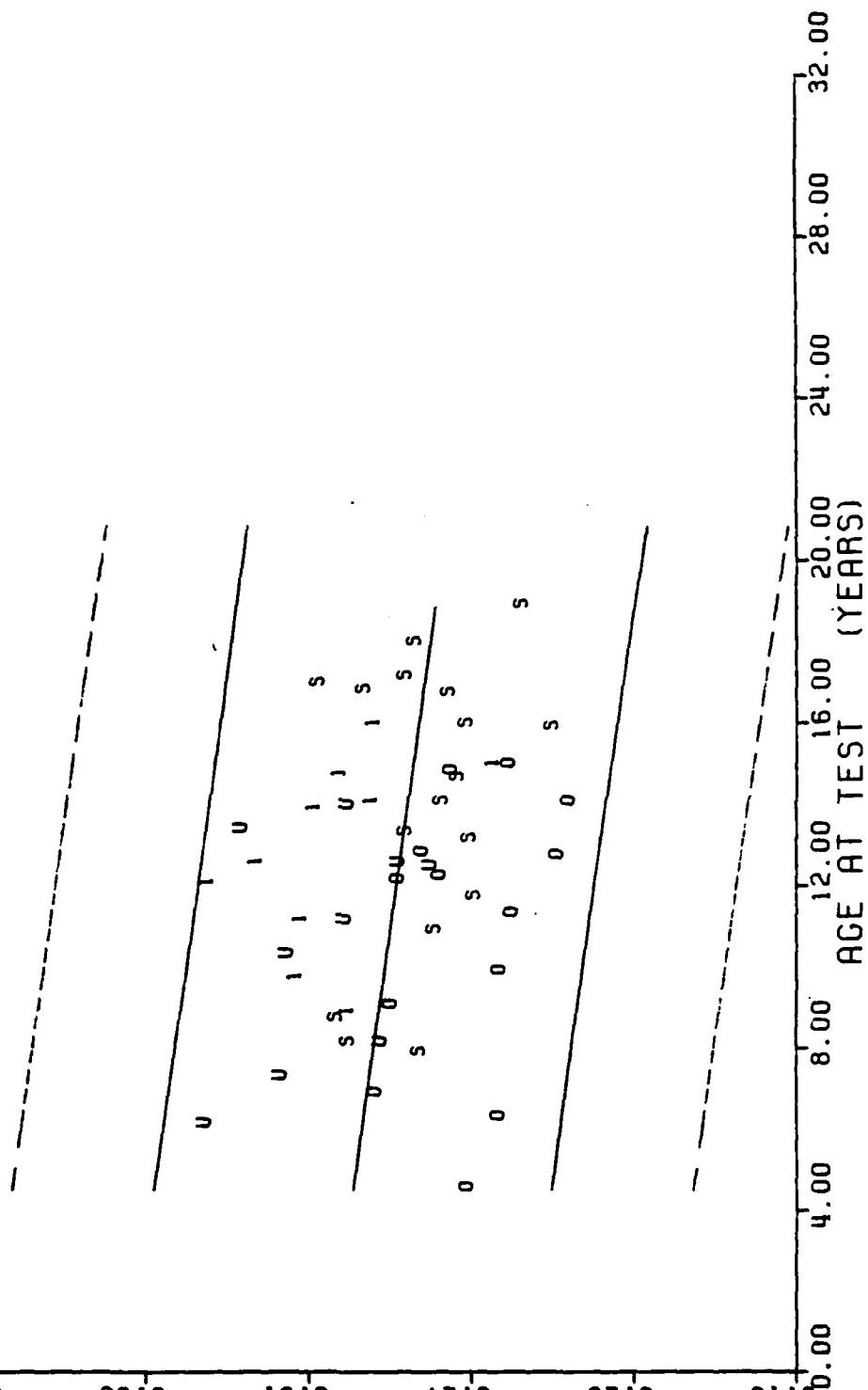
PARAMETER = MAXIMUM STRESS

STAGE 1 DISSECTED MOTORS, LOW RATE CHS=2.0 IN/MIN. MAXIMUM STRESS

Figure 2

$\gamma = ((+3.0547881E-01) + (-1.1880831E-04) * X)$   
 $F = +1.1461158E+01$  SIGNIFICANT OF F = SIGNIFICANT  
 $R = -1.9370296E-01$  SIGNIFICANT OF R = SIGNIFICANT  
 $S_0 = +3.5093974E-05$  SIGNIFICANT OF S<sub>0</sub> = SIGNIFICANT  
 $S_t = +2.7921631E-02$  DEGREES OF FREEDOM = 294  
 $N = 296$  STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = 77 DEG/F AMB-RH

PARAMETER = STRAIN AT RUPTURE  
 UNIT OF MEASURE = IN/IN  
 0.19 0.23 0.27 0.31 0.35 0.39

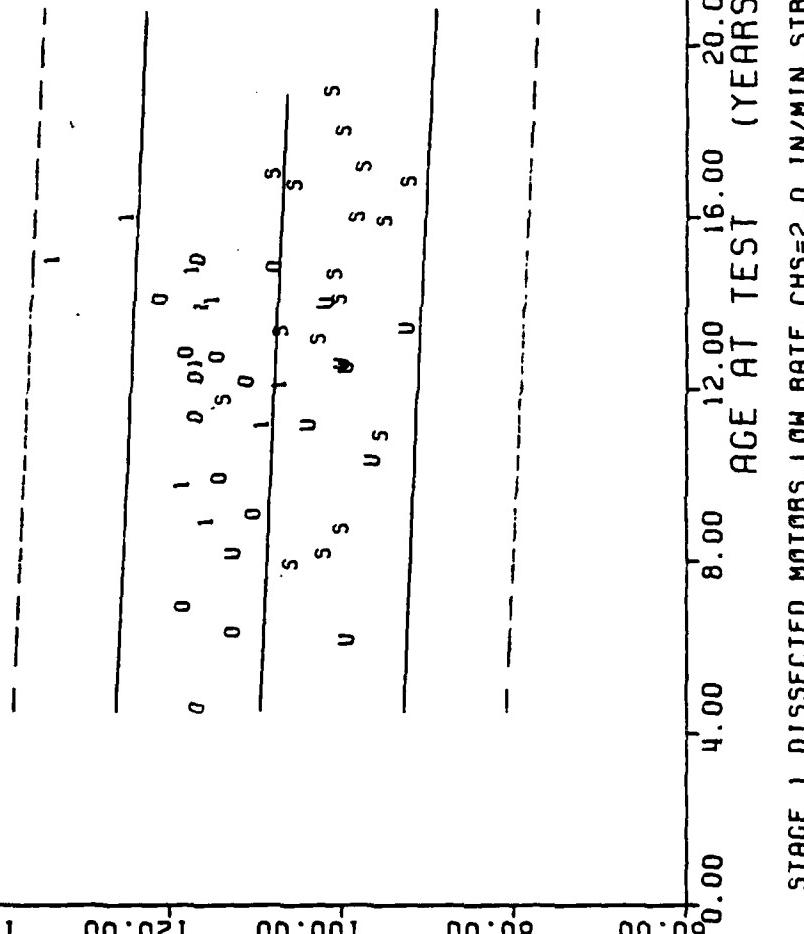


STAGE 1 DISSECTED MOTORS, LOW RATE CHS=2.0 IN/MIN, STRAIN AT RUPTURE

Figure 3

$F = +2.3250284E+00$   
 $R = -8.9335738E-02$   
 $I = +1.5248043E+00$   
 $N = 291$   
 $Y = (( +1.1054341E+02 ) + (-1.8468848E-02 ) * X)$   
 $F = \text{SIGNIFICANCE OF } F = \text{NOT SIGNIFICANT}$   
 $R = \text{SIGNIFICANCE OF } R = \text{NOT SIGNIFICANT}$   
 $I = \text{SIGNIFICANCE OF } I = \text{NOT SIGNIFICANT}$   
 $\text{DEGREES OF FREEDOM} = 289$   
 $\text{STORAGE CONDITIONS} = \text{AMB TEMP/RH}$   
 $\text{TEST CONDITIONS} = \text{AMB TEMP/RH}$

PARAMETER = STRESS AT RUPTURE  
 UNIT OF MEASURE = PSI  
 60.00 80.00 100.00 120.00 140.00 160.00



STAGE 1 DISSECTED MOTORS, LOW RATE CHS=2.0 IN/MIN, STRESS AT RUPTURE

Figure 4

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
54.0	26	168.0	16
73.0	24	175.0	8
82.0	5	176.0	3
87.0	5	177.0	5
94.0	16	179.0	8
97.0	5	190.0	3
104.0	5	191.0	13
106.0	5	200.0	3
108.0	5	201.0	3
123.0	4	203.0	5
130.0	5	205.0	3
133.0	5	215.0	8
135.0	5	226.0	3
144.0	5		
145.0	5		
146.0	2		
149.0	3		
150.0	10		
152.0	2		
153.0	5		
157.0	3		
159.0	24		
160.0	5		
166.0	5		
167.0	5		

STAGE 1 DISSECTED MOTICS, LOW RATE CHS=2.0 IN/MIN, MODULUS

This sample size summary is applicable to figure 5

$F = +2.3006983E+01$      $\gamma = (( +9.4887984E+02 ) + ( +1.4157983E+00 ) * X)$   
 $R = +2.8263655E-01$     SIGNIFICANCE OF F = SIGNIFICANT  
 $\alpha = +4.7965595E+00$     SIGNIFICANCE OF R = SIGNIFICANT  
 $N = 267$     SIGNIFICANCE OF  $\gamma$  = SIGNIFICANT  
DEGREES OF FREEDOM = 265    TEST CONDITIONS = AMB TEMP/RH

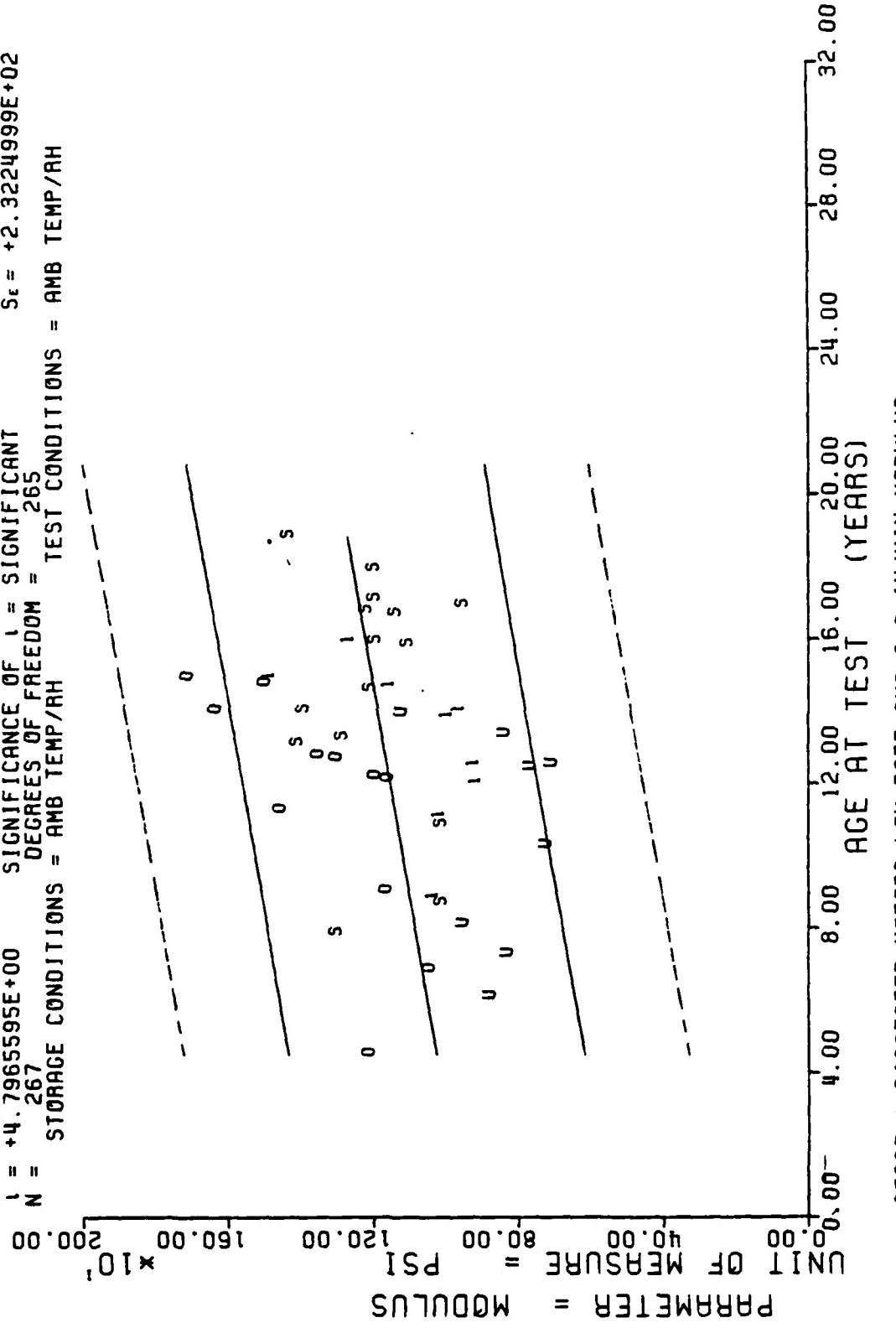


Figure 5

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
82.0	2	177.0	2
97.0	5	179.0	6
104.0	2	190.0	3
106.0	5	191.0	13
108.0	5	200.0	3
116.0.C	6	201.0	3
118.0	5	203.0	5
123.0	5	205.0	3
130.0	5	215.0	5
133.0	14	226.0	3
135.0	3		
140.0	5		
144.0	4		
145.0	3		
146.0.C	2		
150.0	9		
152.0	3		
153.0	5		
157.0	7		
160.0	5		
166.0	6		
167.0	7		
168.0	15		
175.0	8		
176.0	3		

STAGE 1 DISSECTED MOTORS.LC% RATE CHS=20.0 IN/MIN.STRAIN MAX STRESS

This sample size summary is applicable to figures 6 thru 9

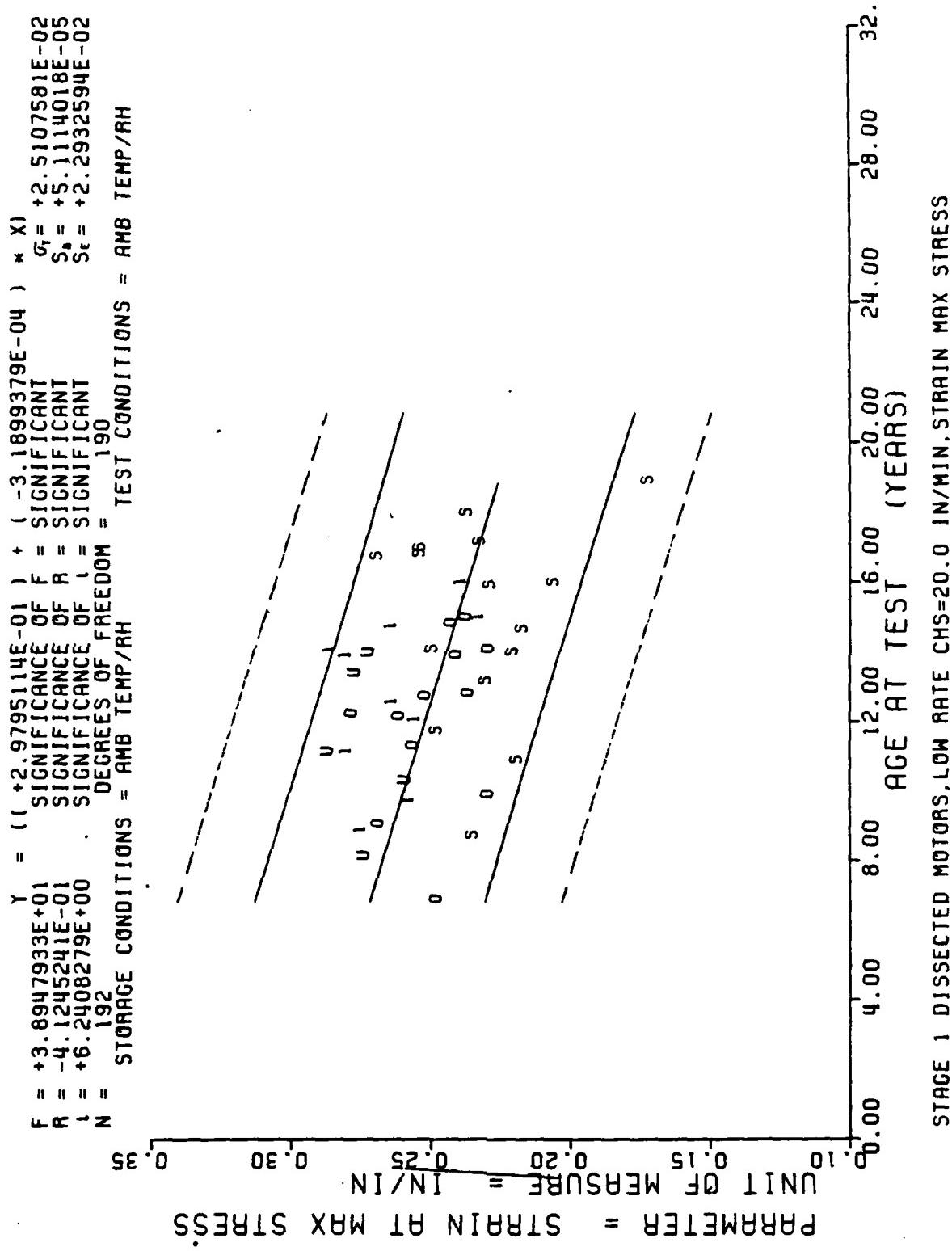
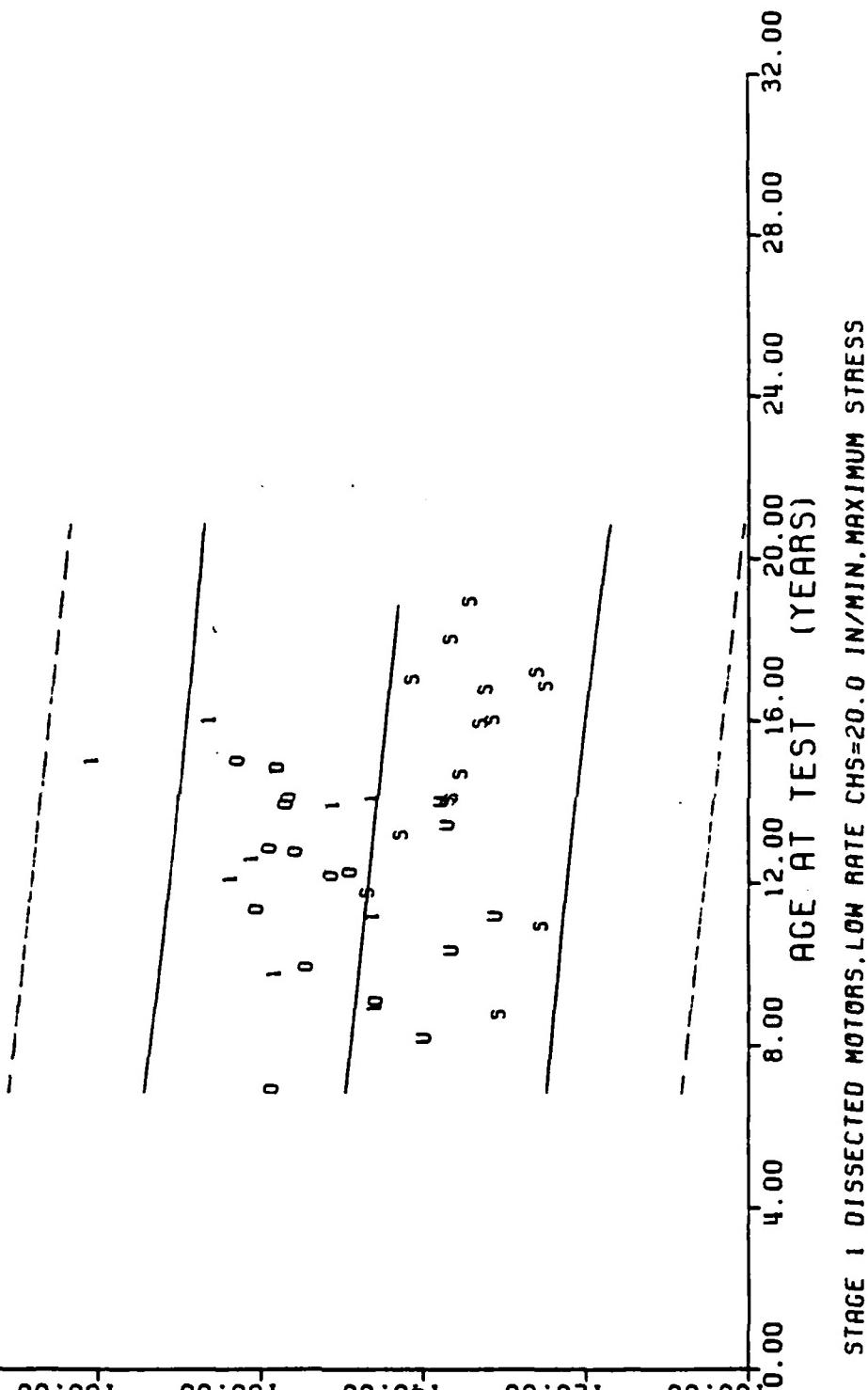


Figure 6

$\gamma = ((+1.5336050E+02) + (-4.5525406E-02) * X)$   
 $F = +2.1877265E+00$  SIGNIFICANT OF F = NOT SIGNIFICANT  
 $R = -1.0669245E-01$  SIGNIFICANT OF R = NOT SIGNIFICANT  
 $I = +1.4790965E+00$  SIGNIFICANT OF I = NOT SIGNIFICANT  
 $N = 192$  DEGREES OF FREEDOM = 190  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

PARAMETER = MAXIMUM STRESS  
 UNIT OF MEASURE = PSI



STAGE 1 DISSECTED MOTORS, LOW RATE CHS=20.0 IN/MIN, MAXIMUM STRESS

Figure 7

$F = +1.7307197E+01$       SIGNIFICANCE OF  $F$  = SIGNIFICANT  
 $R = -2.8893901E-01$       SIGNIFICANCE OF  $R$  = SIGNIFICANT  
 $L = +4.1601920E+00$       SIGNIFICANCE OF  $L$  = SIGNIFICANT  
 $N = 192$       DEGREES OF FREEDOM = 190  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

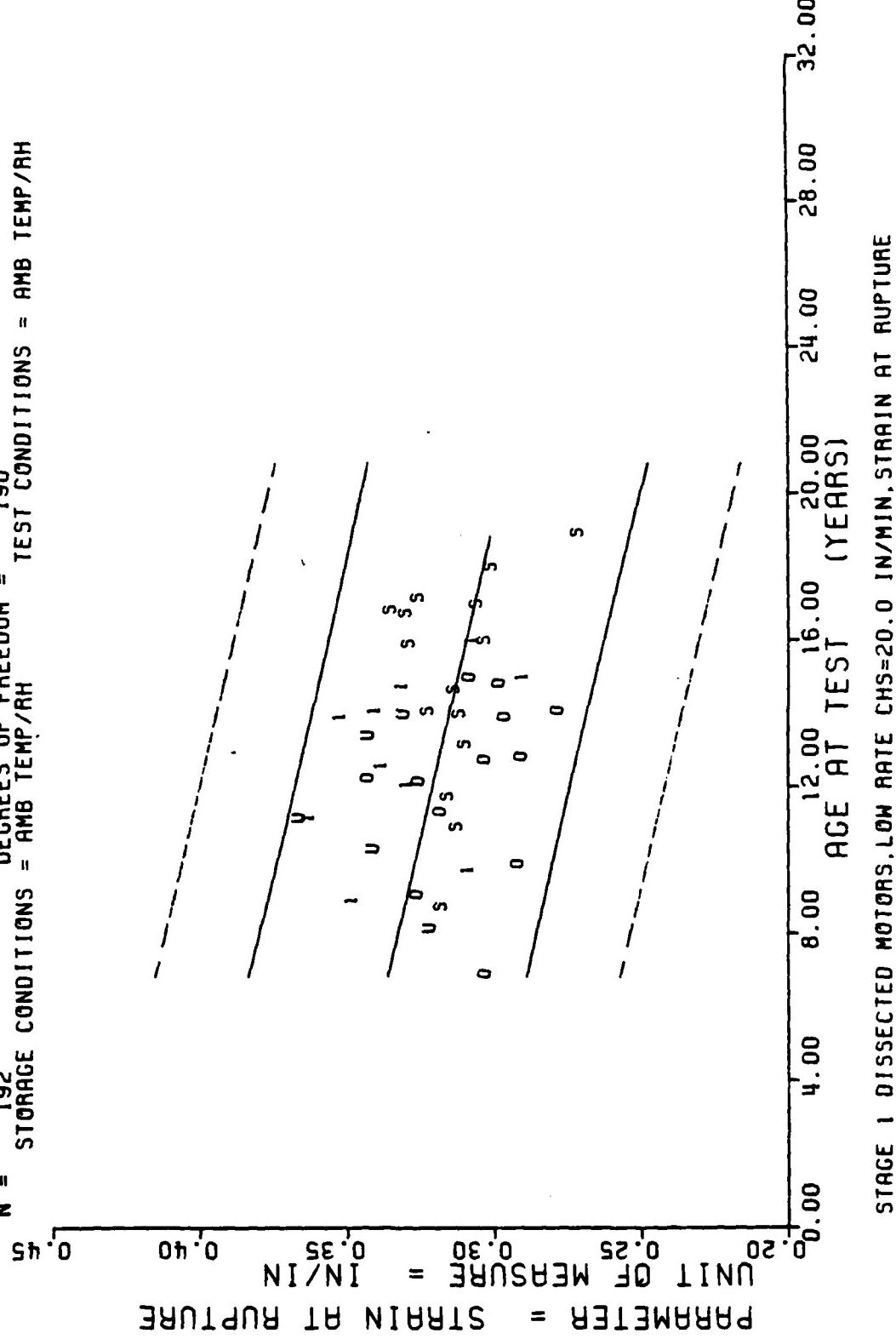
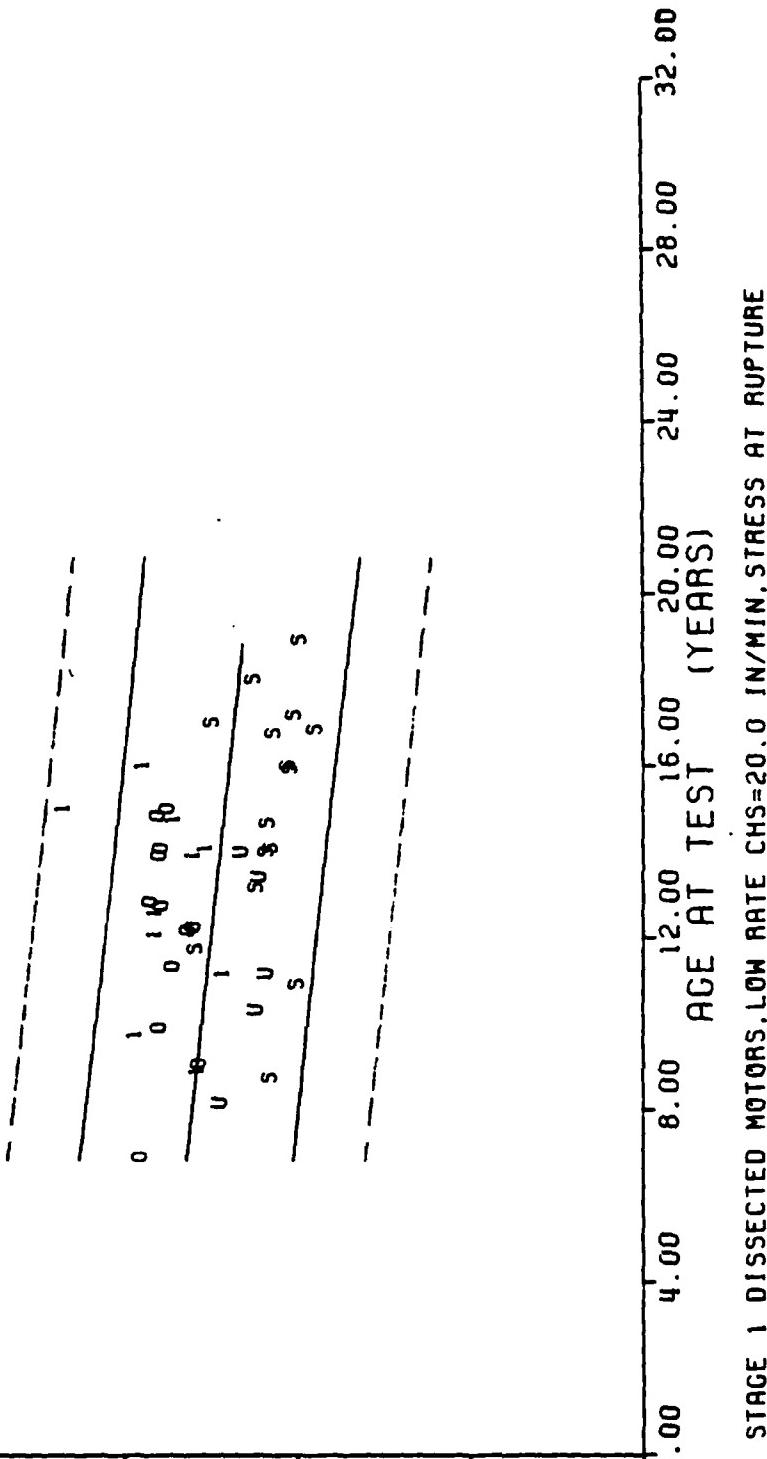


Figure 8

$F = +8.9934730E+00$       SIGNIFICANCE OF F = SIGNIFICANT       $\sigma_t = +1.4077538E+01$   
 $R = -2.1259071E-01$       SIGNIFICANCE OF R = SIGNIFICANT       $S_b = +3.0740493E-02$   
 $t = +2.9989119E+00$       SIGNIFICANCE OF t = SIGNIFICANT       $S_c = +1.3791896E+01$   
 $N = 192$       DEGREES OF FREEDOM = 190  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

PARAMETER = STRESS RT RUPTURE      UNIT OF MEASURE = PSI  
 0.00 400.00 800.00 1200.00 1600.00 2000.00 2400.00



STAGE 1 DISSECTED MOTORS, LOW RATE CHS=20.0 IN/MIN. STRESS AT RUPTURE

Figure 9

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

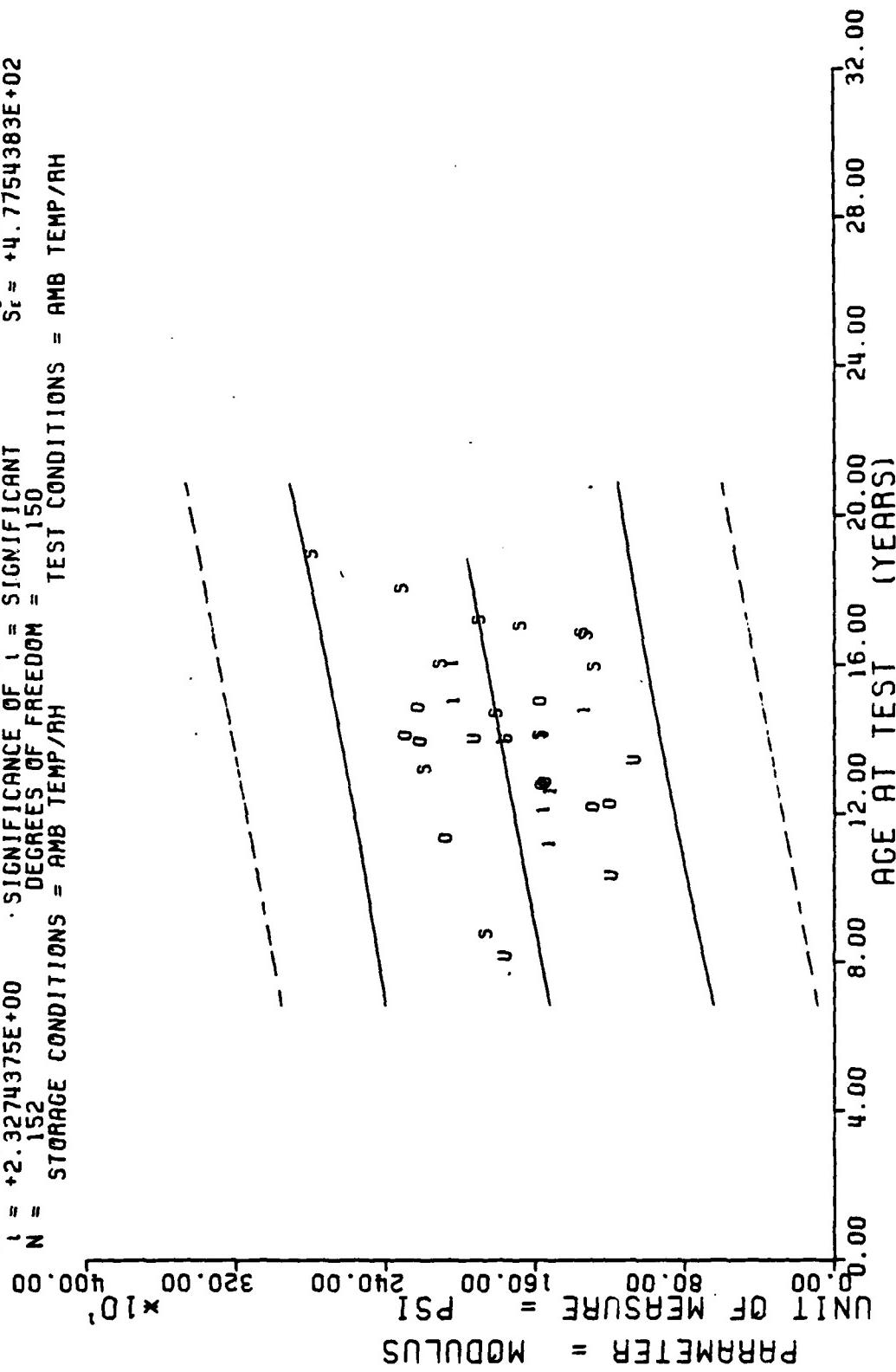
AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
82.0	2	203.0	5
97.0	5	205.0	3
104.0	2	215.0	5
123.0	2	226.0	2
133.0	6		
135.0	6		
144.0	4		
145.0	2		
146.0	9		
150.0	5		
152.0	5		
153.0	5		
157.0	7		
160.0	5		
166.0	8		
167.0	7		
168.0	15		
175.0	8		
176.0	2		
177.0	2		
179.0	6		
190.0	15		
191.0	15		
200.0	15		
201.0	15		

STAGE 1 DISSECTED NCYCFS,LOW RATE CH-S=20.0 IN/MIN.MODULUS

This sample size summary is applicable to figure 10

$$\begin{aligned}
 F &= +5.4169657E+00 & Y &= ((+1.2738665E+03) + (+3.0380642E+00) * X) \\
 R &= +1.8669334E-01 & S_f &= +4.8447791E+02 \\
 I &= +2.3274375E+00 & S_r &= +1.3053257E+00 \\
 N &= 152 & .SIGNIFICANCE OF F &= SIGNIFICANT \\
 && .SIGNIFICANCE OF R &= SIGNIFICANT \\
 && .SIGNIFICANCE OF I &= SIGNIFICANT \\
 && DEGREES OF FREEDOM &= 150 \\
 \text{STORAGE CONDITIONS} &= \text{AMB TEMP/RH} & \text{TEST CONDITIONS} &= \text{AMB TEMP/RH}
 \end{aligned}$$

STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH  
 $+2.3274375E+00$  . SIGNIFICANCE OF  $\Delta$  = SIGNIFICANT  
 $152$  DEGREES OF FREEDOM =  $150$        $S_e = +4.77543$



## STAGE 1 DISSECTED MASTERS | 10W RATE CHS=20.0 IN/MIN. WOOD

Figure 10

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
60.0	6	226.0	6
71.0	4		
80.0	16		
83.0	5		
93.0	6		
105.0	6		
107.0	5		
109.0	5		
114.0	6		
118.0	6		
131.0	5		
134.0	4		
136.0	6		
141.0	6		
144.0	5		
146.0	5		
151.0	5		
154.0	5		
158.0	5		
176.0	5		
177.0	6		
179.0	5		
191.0	5		
201.0	5		
202.0	6		

STAGE I DISSECTED MOTES, HIGH RATE CPS=1750 IN/MIN. STRAIN MAX STRESS

This sample size summary is applicable to figures 11 thru 15

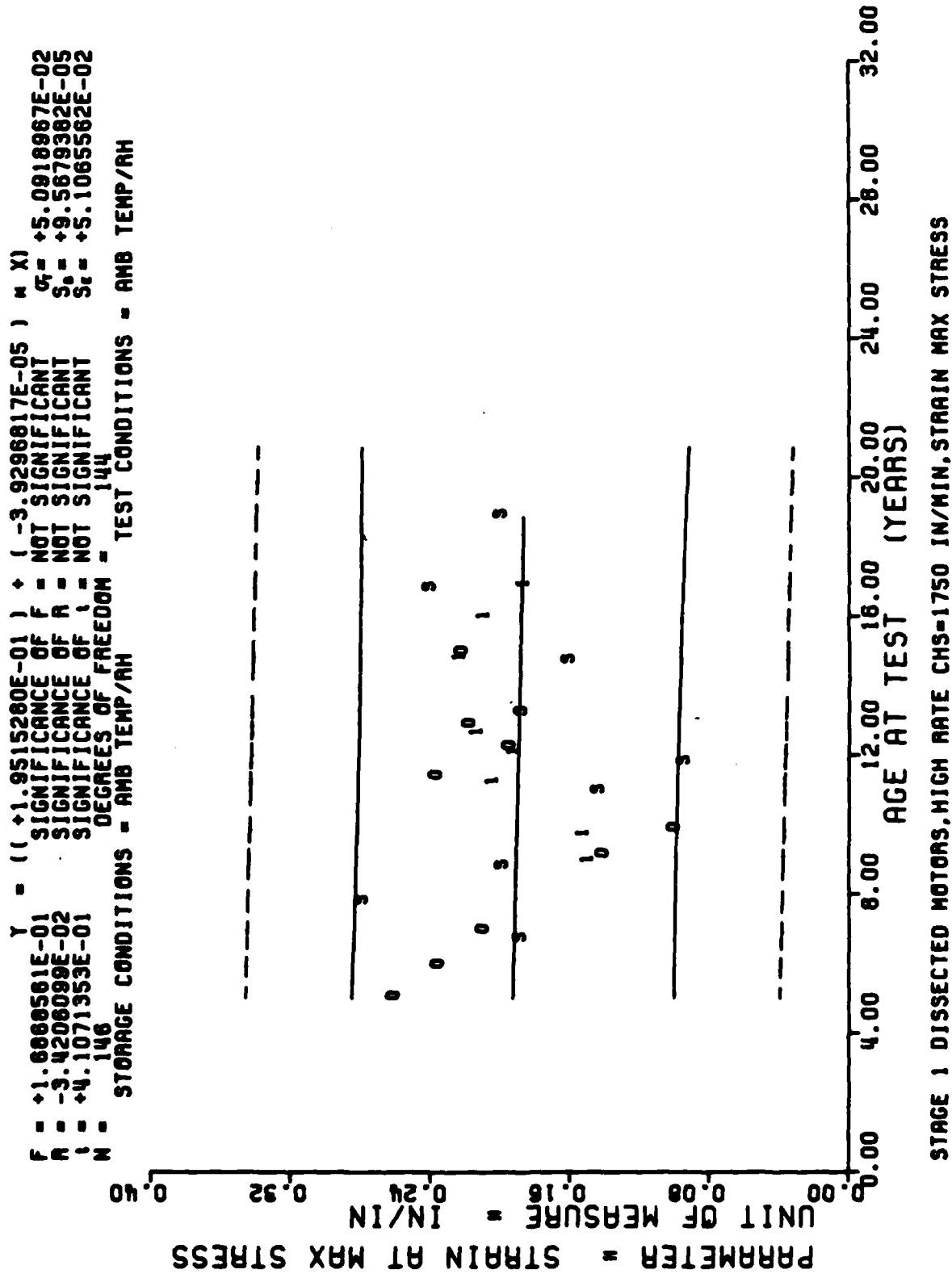


Figure 11

$F = +9.6750031E-01$        $\gamma = (1 + 3.4370114E+02) + (-7.2498092E-02)$        $n = X$   
 $F = \text{NOT SIGNIFICANT}$        $\gamma = \text{NOT SIGNIFICANT}$        $n = +3.9332221E+01$   
 $R = -6.1697703E-02$        $F = \text{NOT SIGNIFICANT}$        $S_r = +7.3703355E-02$   
 $R = +9.6366066E-01$        $F = \text{NOT SIGNIFICANT}$        $S_s = +3.9336610E+01$   
 $I = 146$        $Degrees of Freedom = 144$   
 $N =$       **STORAGE CONDITIONS - AMB TEMP/RH      TEST CONDITIONS - AMB TEMP/RH**

UNIT OF MEASURE = PSI  
 PARAMETER = MAXIMUM STRESS  
 0.00 240.00 320.00 400.00 480.00 560.00

- 28 -

STAGE 1 DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN, MAXIMUM STRESS

Figure 12

$y = ((+3.3810743E-01) + (+6.8475750E-06) \times x)$   
 $F = +1.4700791E-02$  SIGNIFICANCE OF F = NOT SIGNIFICANT  
 $R = +1.0103386E-02$  SIGNIFICANCE OF R = NOT SIGNIFICANT  
 $I = +1.2124882E-01$  SIGNIFICANCE OF I = NOT SIGNIFICANT  
 $N = 146$  DEGREES OF FREEDOM = 144  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

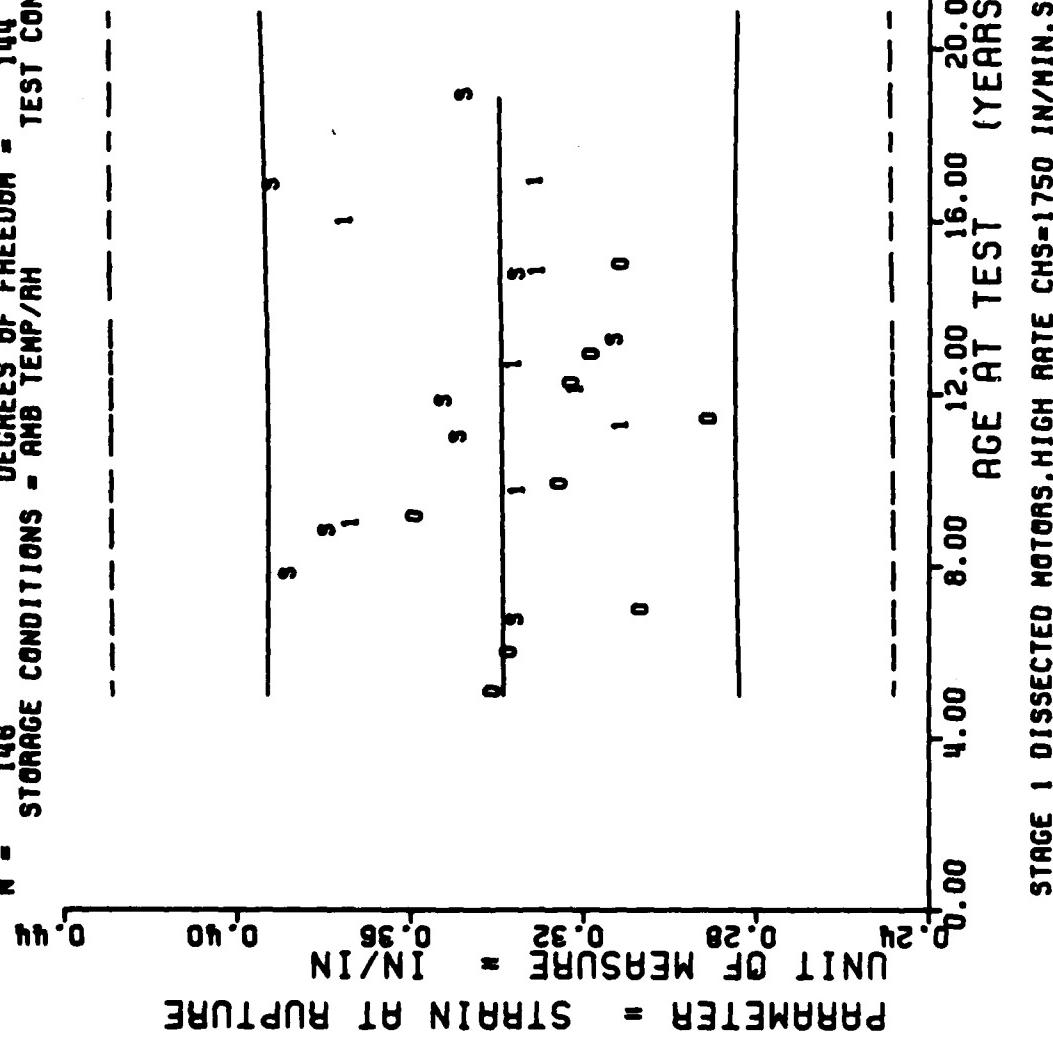
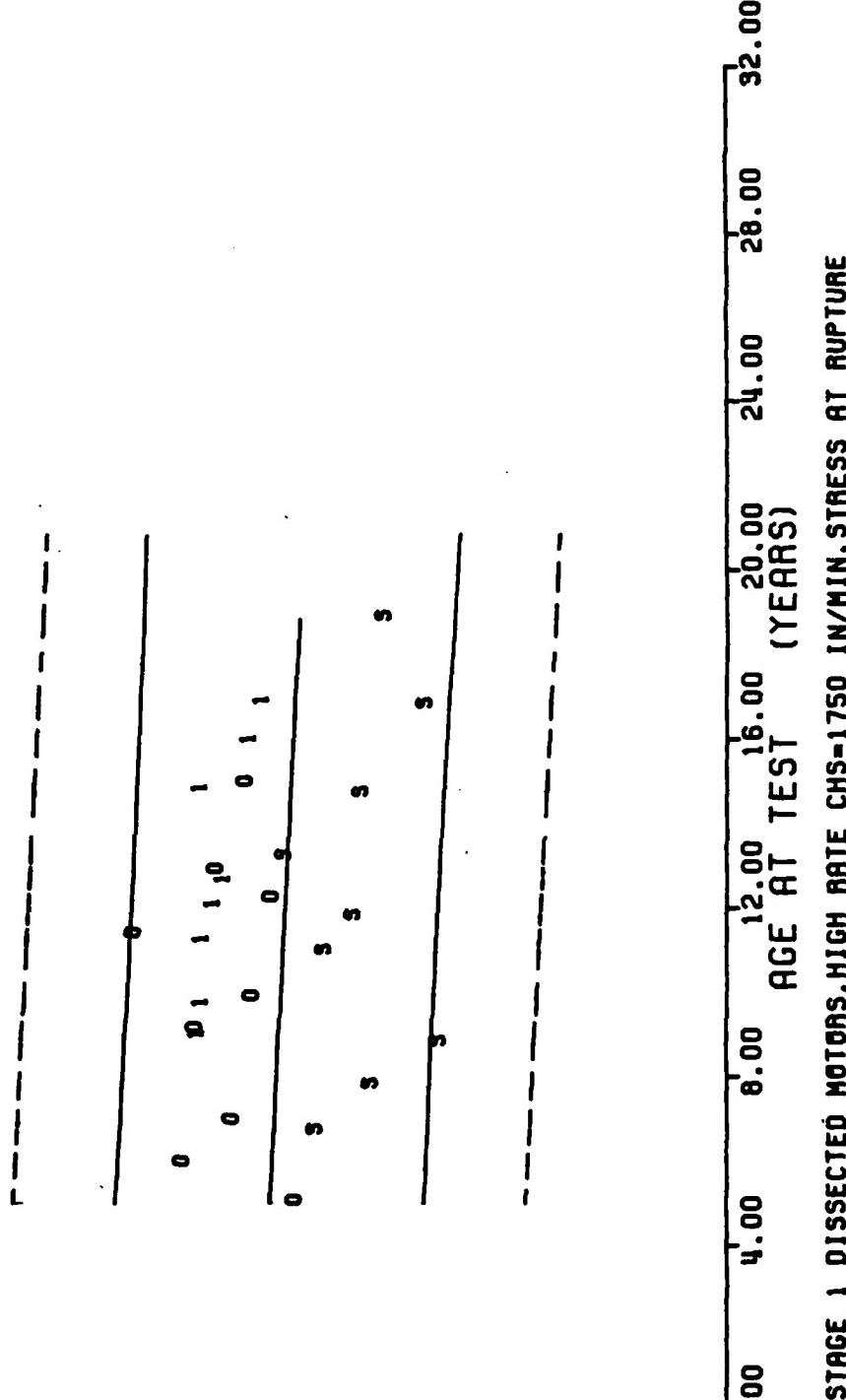


Figure 13

$\gamma = (( +3.0158341E+02 ) + ( -8.6619611E-02 ) \times X)$   
 $F = +1.3069879E+00$  SIGNIFICANCE OF F = NOT SIGNIFICANT  
 $R = -9.4840217E-02$  SIGNIFICANCE OF R = NOT SIGNIFICANT  
 $t = +1.1432357E+00$  SIGNIFICANCE OF t = NOT SIGNIFICANT  
 $N = 146$  DEGREES OF FREEDOM = 144  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

PARAMETER = STRESS AT RUPTURE  
 UNIT OF MEASURE = PSI  
 80.00 160.00 240.00 320.00 400.00 480.00

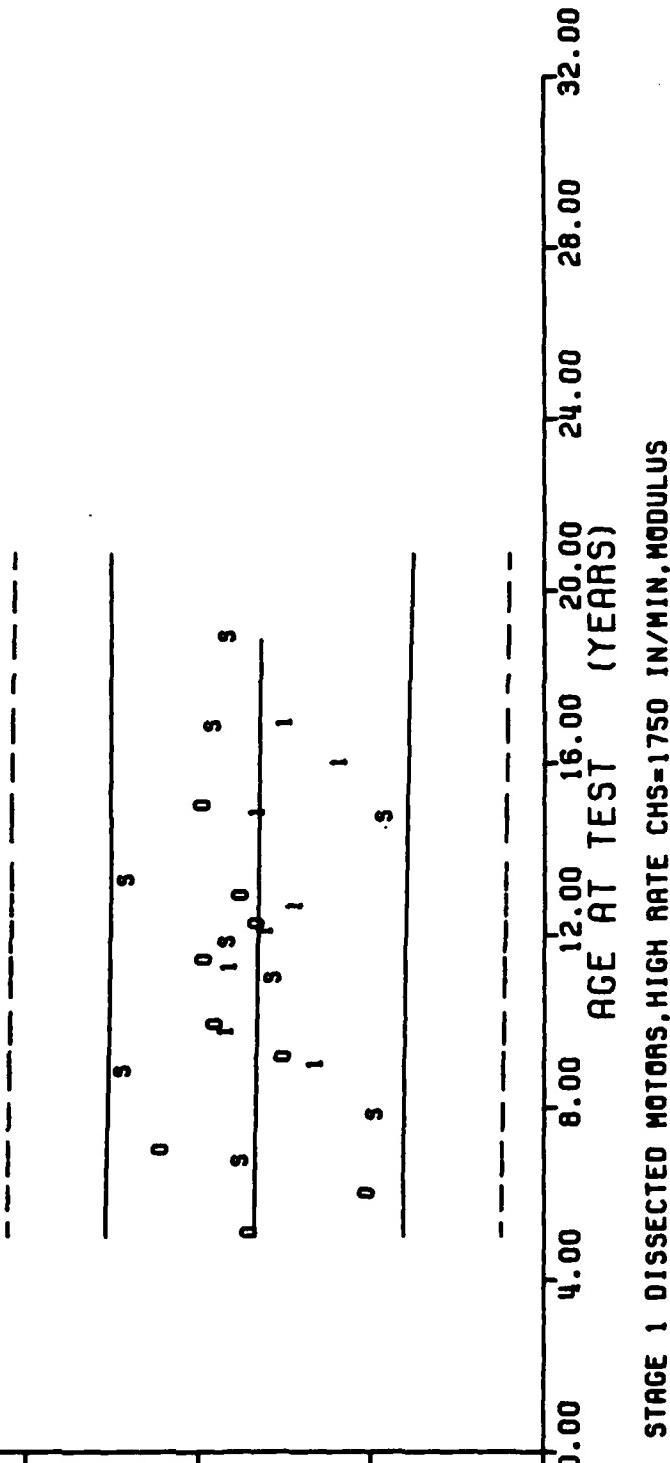


STAGE 1 DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN, STRESS AT RUPTURE

Figure 14

$\gamma = (( +6.7734457E+03) + (-1.0380077E+00)) \times X$   
 $F = 4426976E-02$  SIGNIFICANCE OF F = NOT SIGNIFICANT  
 $R = -2.4206505E-02$  SIGNIFICANCE OF R = NOT SIGNIFICANT  
 $s_r = +3.5723991E+00$   
 $t = +2.9056320E-01$  SIGNIFICANCE OF T = NOT SIGNIFICANT  
 $s_t = +1.9066445E+03$   
 $N = 146$  DEGREES OF FREEDOM = 144  
 $N =$  STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

UNIT OF MEASURE = PSI  $\times 10^2$   
 PARAMETER = MODULUS



STAGE 1 DISSECTED MOTORS, HIGH RATE CHS=1750 IN/MIN. MODULUS

Figure 15

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES
71.0	2
72.0	8
83.0	2
93.0	2
105.0	2
108.0	2
110.0	2
132.0	2
134.0	4
136.0	2
144.0	2
146.0	2
151.0	3
153.0	3
158.0	2
168.0	2
175.0	3
177.0	3
179.0	3
181.0	2
201.0	3
202.0	3
215.0	3
226.0	2

DISSECTED TP-H-101.H.R.TRIAXIAL CHS=1750 IN/MIN, 600 PSI, STPAIN MAX STRESS

This sample size summary is applicable to figures 16 thru 20

$\gamma = (( +1.1804317E-01) + (+7.5954832E-04) * X)$   
 $F = \text{SIGNIFICANT}$   
 $R = \text{SIGNIFICANT}$   
 $r = \text{SIGNIFICANT}$   
 $\sigma_f = +4.5477031E-02$   
 $s_i = +7.2745127E-05$   
 $s_r = +2.7874149E-02$   
 $N = 66$   
 $Degrees of Freedom = 64$   
 $Storage Conditions = AMB TEMP/RH$   
 $Test Conditions = AMB TEMP/RH$

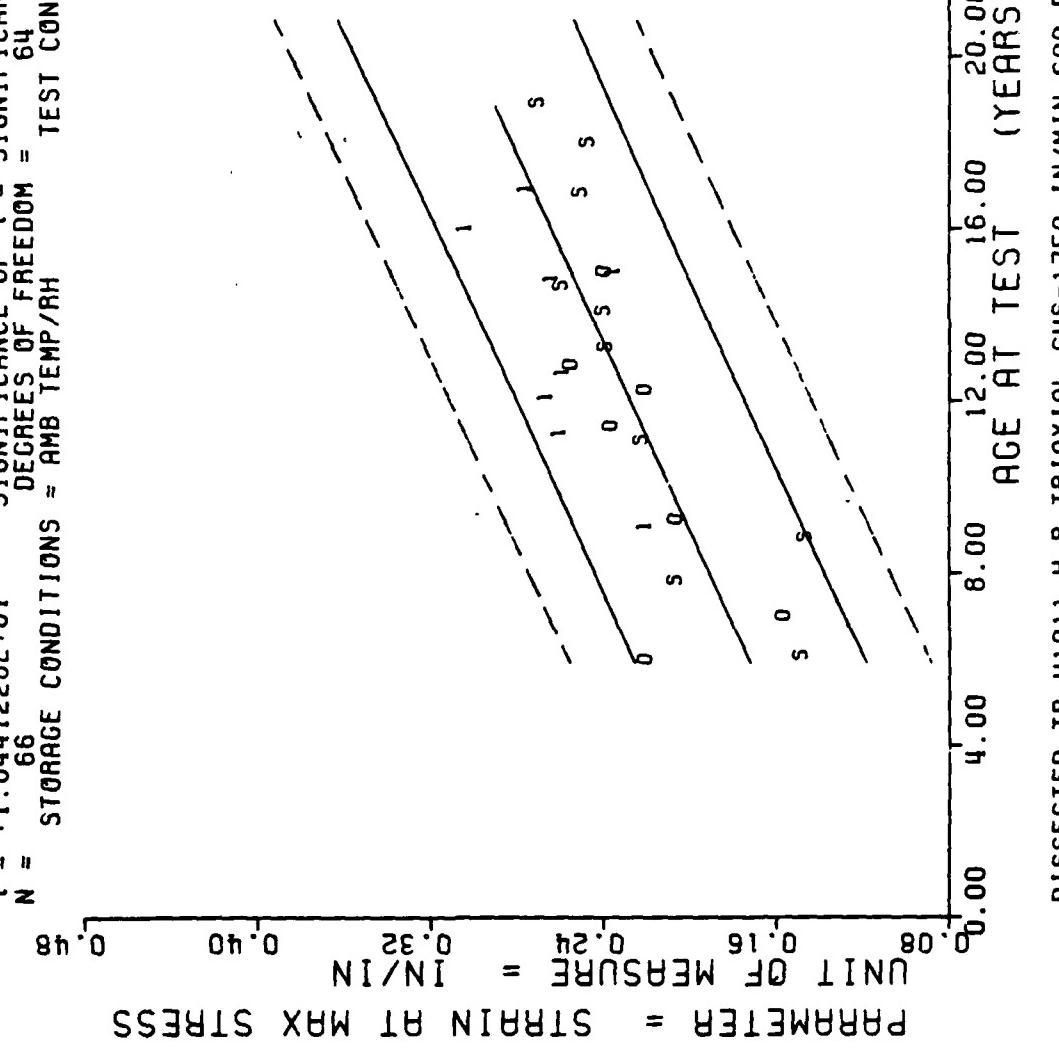


Figure 16

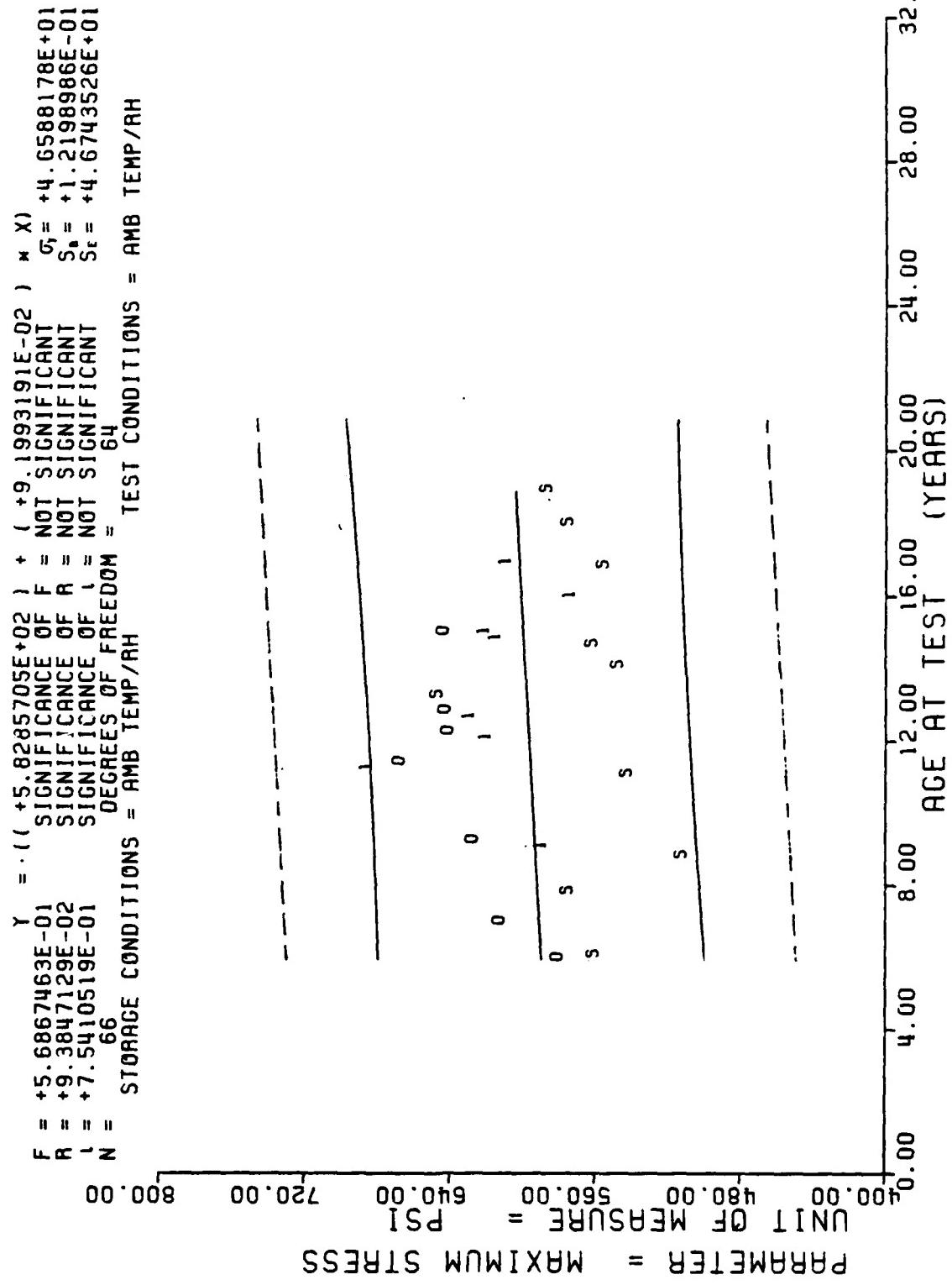


Figure 17

$F = +7.3120777E+01$        $\gamma = (( +1.8066666E-01 ) + ( +6.3604365E-04 ) * X)$   
 $R = +7.3024529E-01$       SIGNIFICANCE OF  $F = \text{SIGNIFICANT}$   
 $I = +8.5510687E+00$       SIGNIFICANCE OF  $R = \text{SIGNIFICANT}$   
 $N = 66$       SIGNIFICANCE OF  $I = \text{SIGNIFICANT}$   
 $64$       DEGREES OF FREEDOM  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

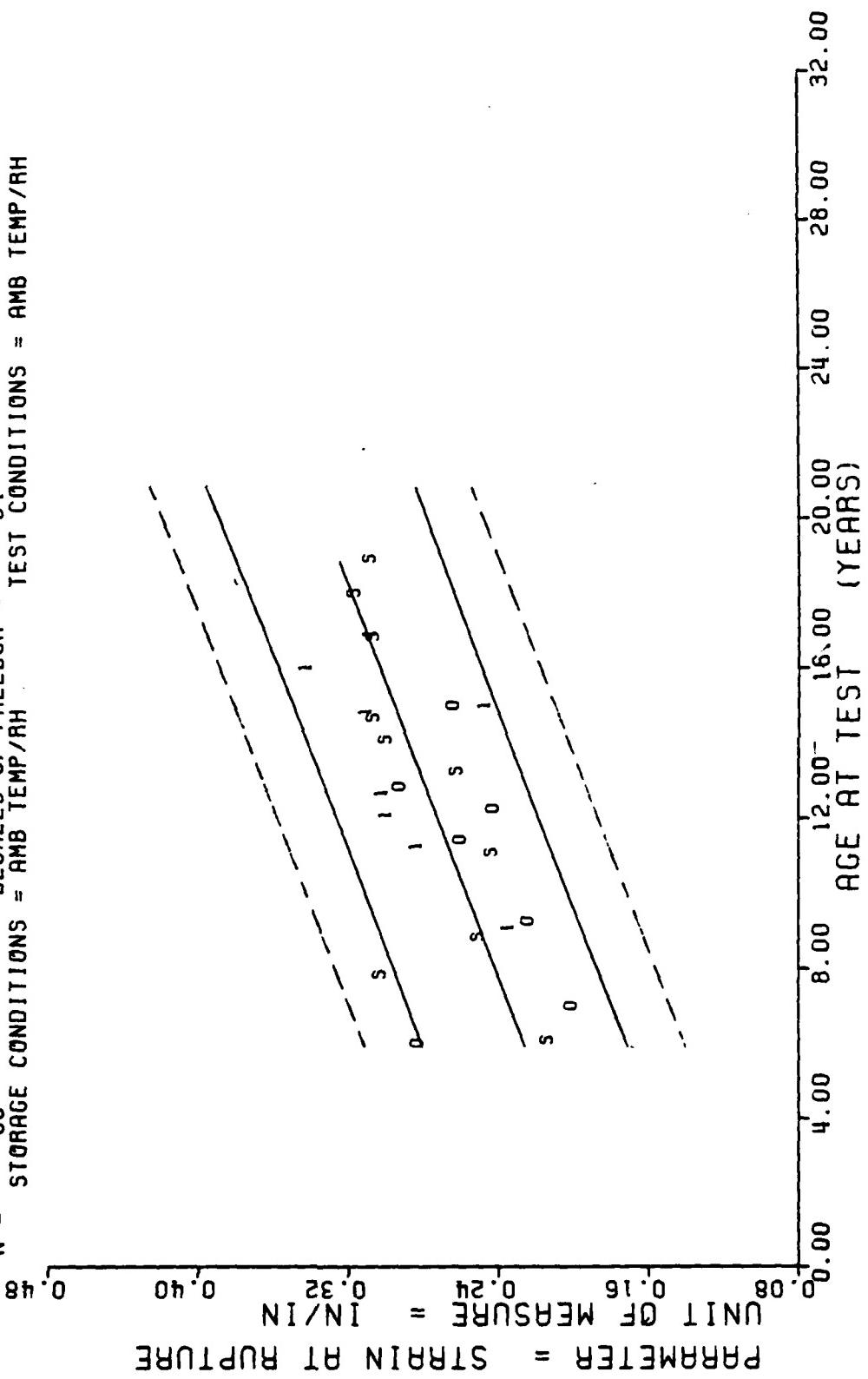


Figure 18

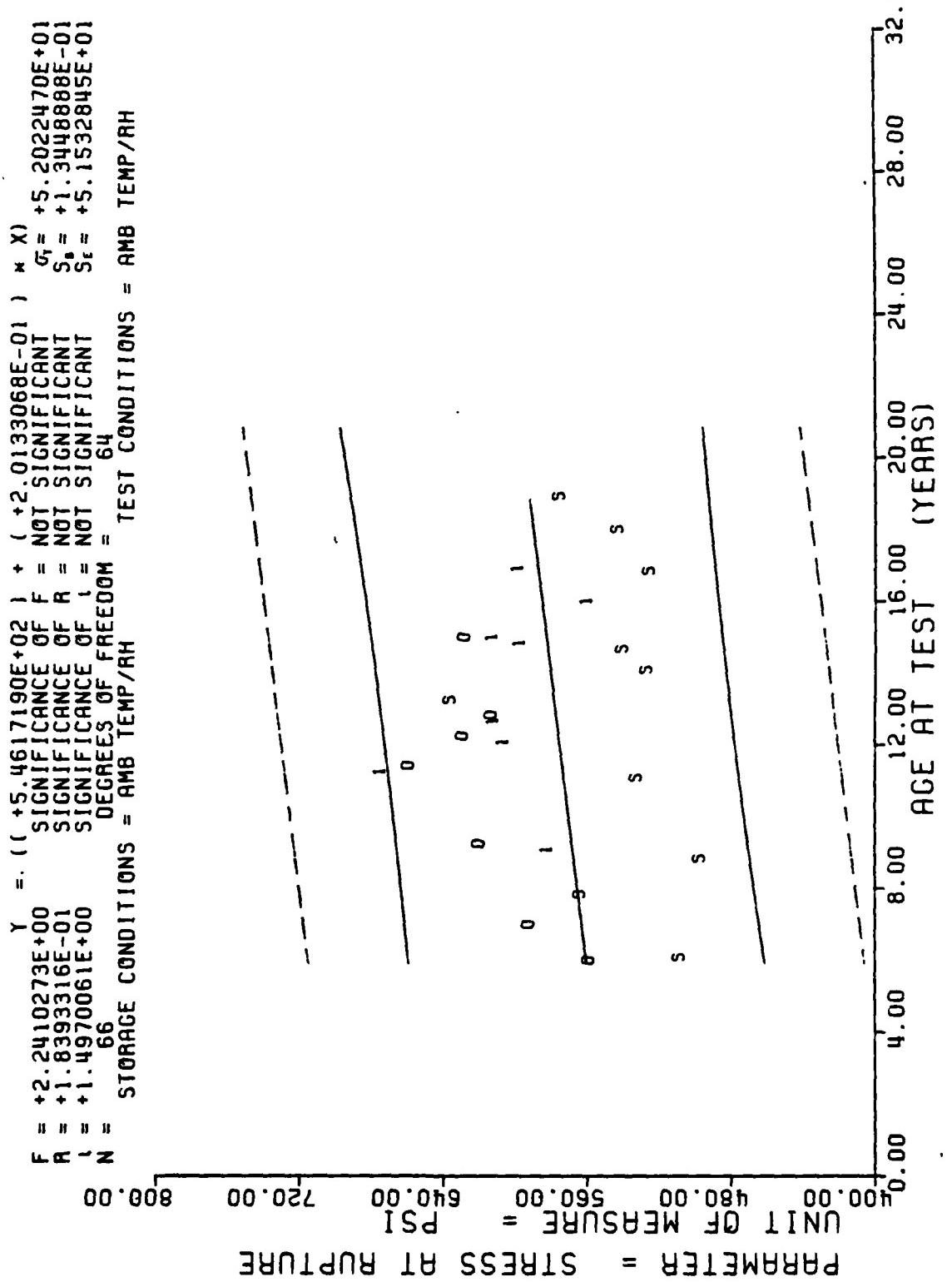


Figure 19

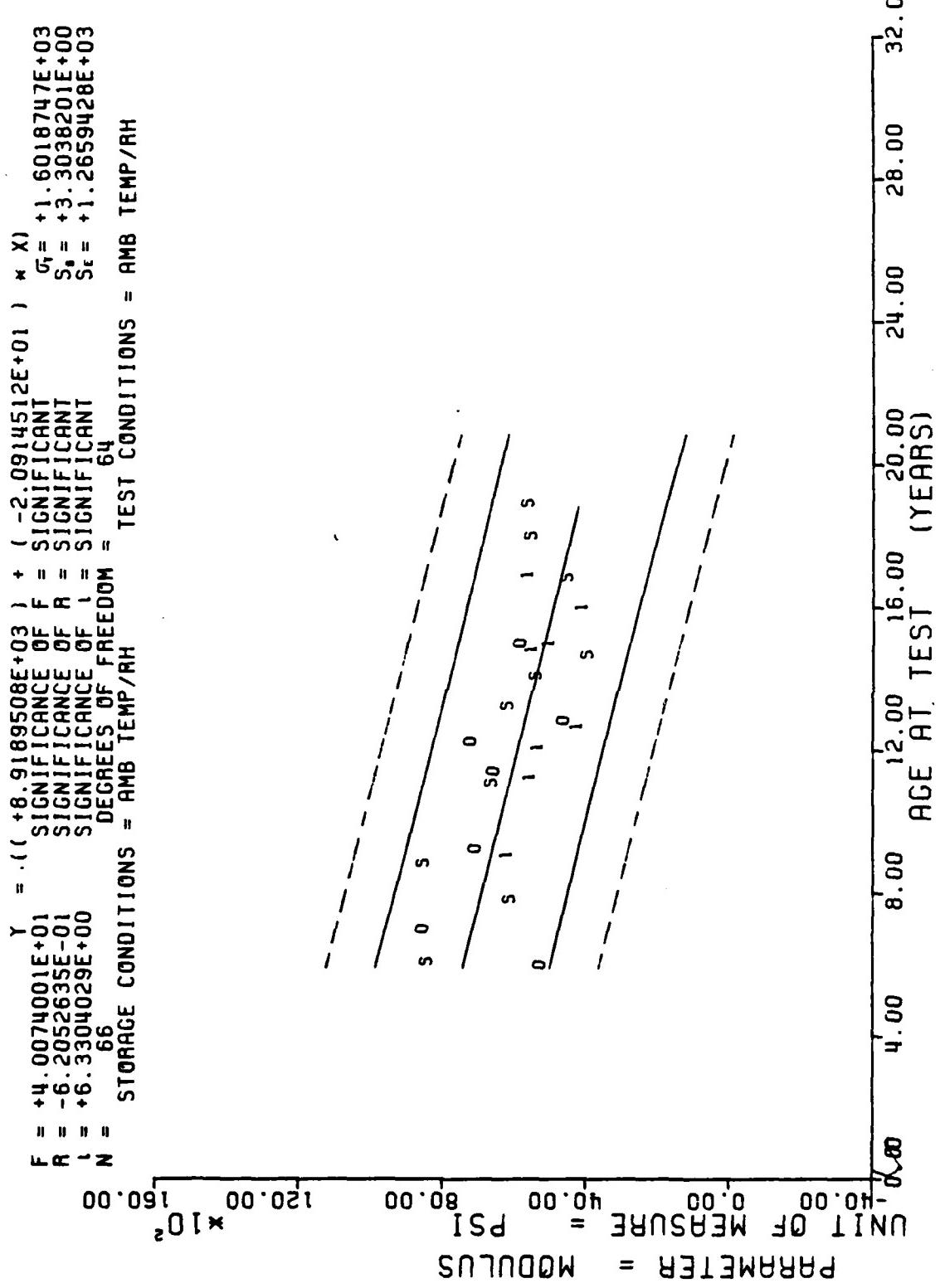


Figure 20

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES
80.0	27
94.0	2
104.0	10
113.0	12
116.0	12
141.0	11
164.0	9
156.0	22
166.0	9
177.0	10
178.0	8
189.0	11
201.0	12
202.0	4
216.0	10
226.0	10

CASEBOARD TENSILE, STAGE 1 DISSECTED, CHS 0.2, CSA 0.75

This sample size summary is applicable to figure 21

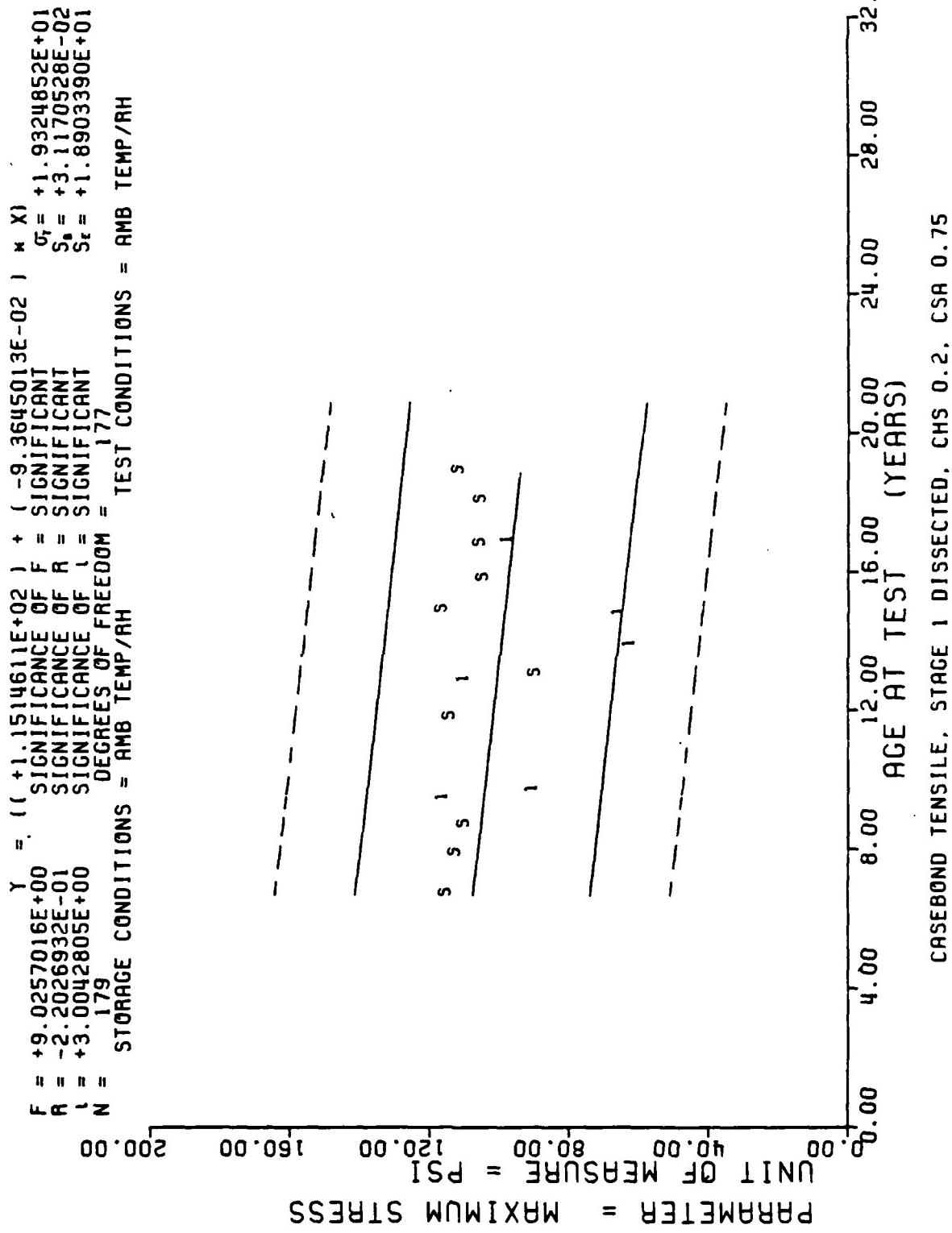


Figure 21

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
72.0	2	190.0	3
76.0	3	200.0	3
84.0	2	226.0	2
87.0	2		
94.0	2		
99.0	2		
106.0	3		
108.0	1		
123.0	1		
130.0	1		
132.0	2		
134.0	2		
144.0	2		
146.0	2		
149.0	2		
151.0	4		
153.0	3		
157.0	1		
160.0	2		
166.0	2		
167.0	4		
168.0	6		
175.0	2		
176.0	4		
178.0	3		

DISSTILLED WATER T/F-H1011, KEEP 10 LB LOAD, COMPLIANCE AT 10 SEC.

This sample size summary is applicable to figures 22, 23 and 24

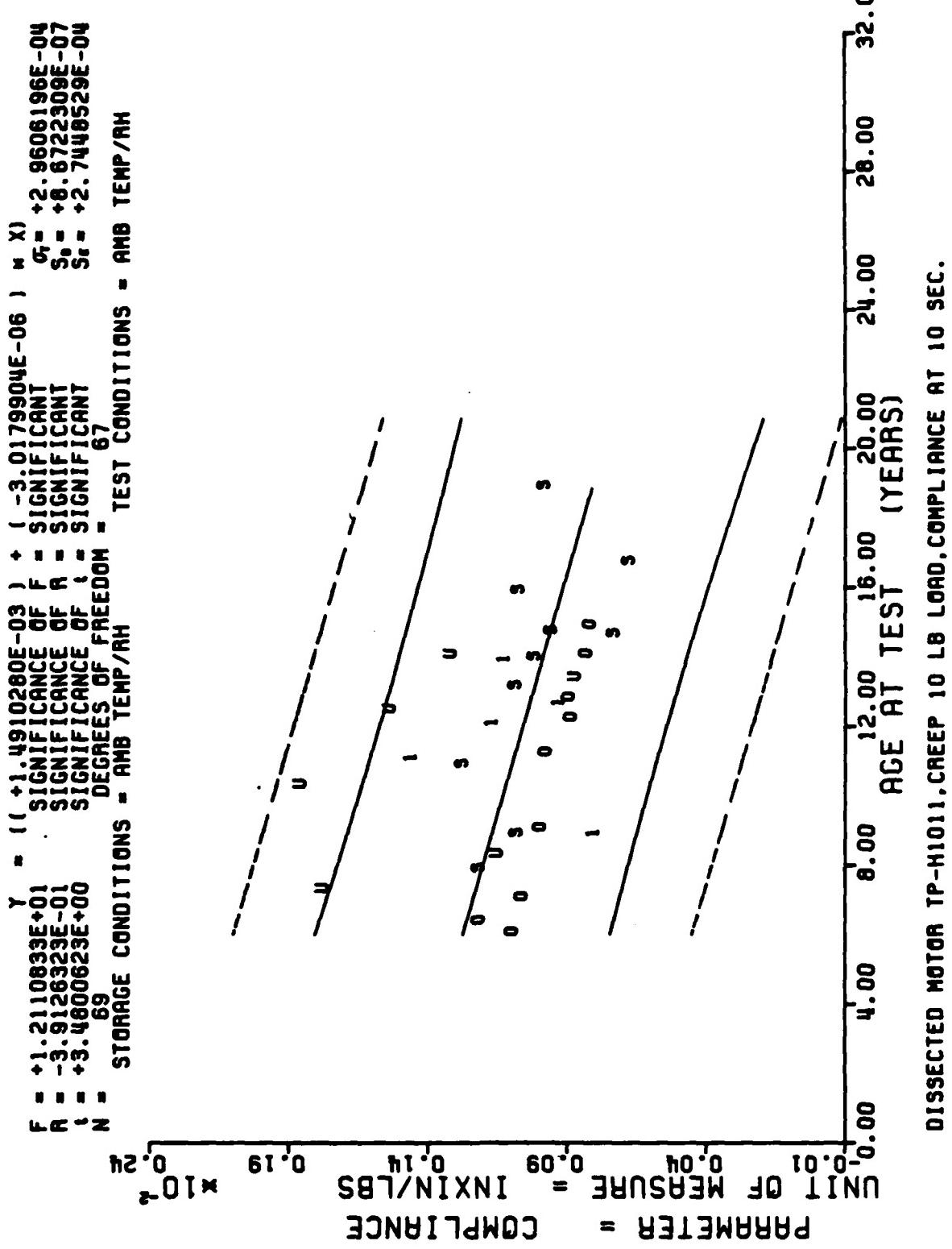


Figure 22

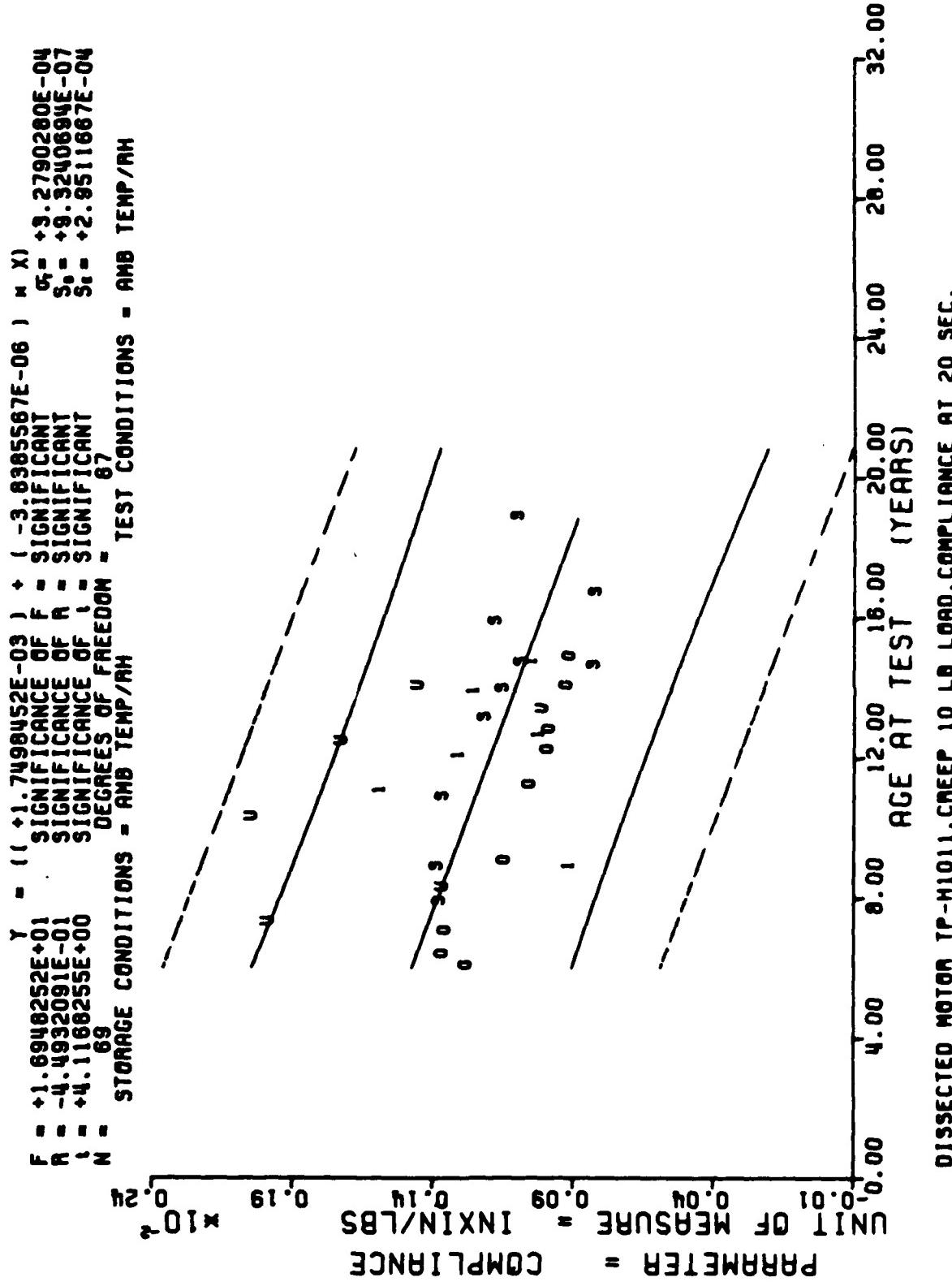


Figure 21

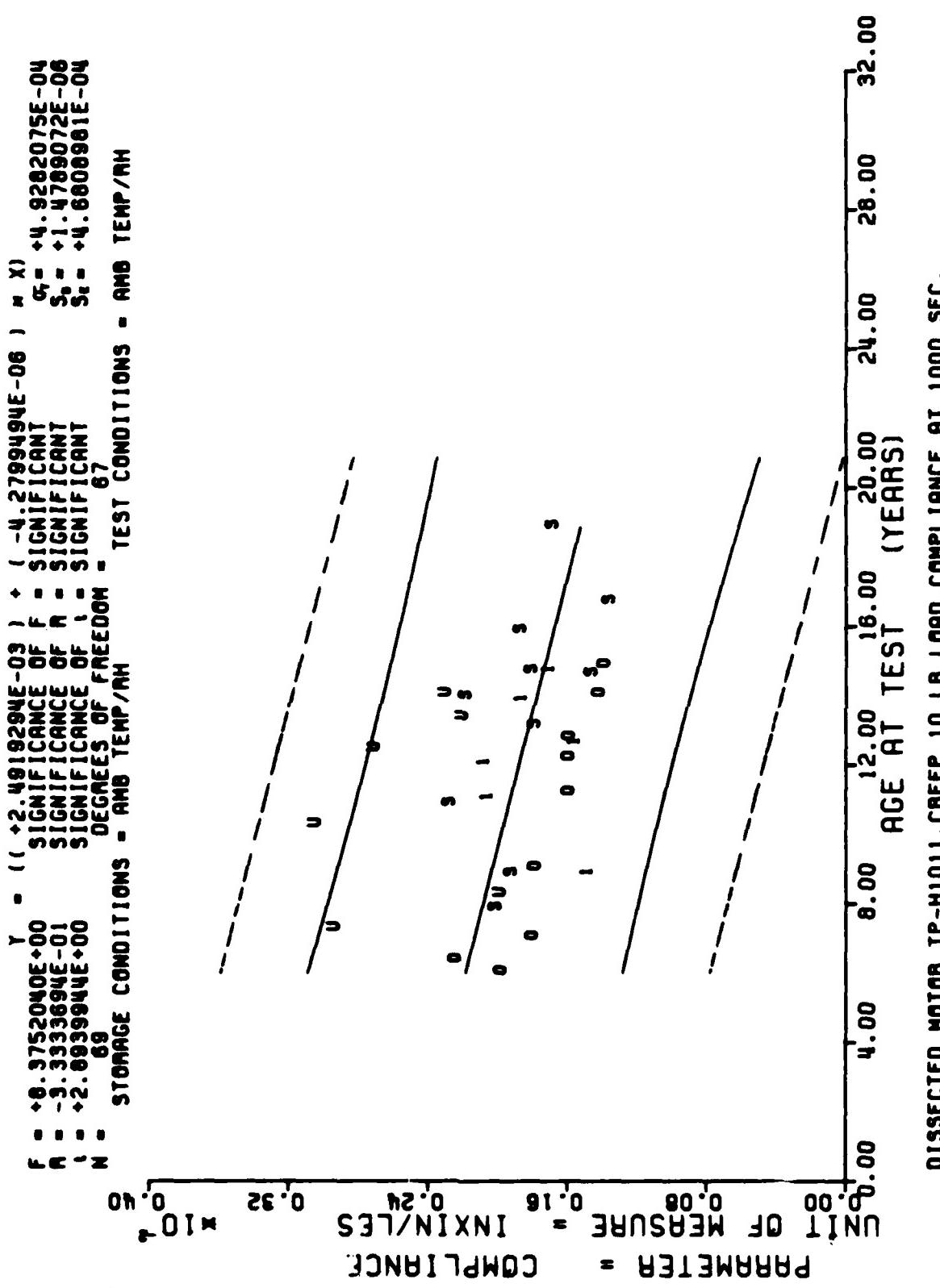


Figure 24

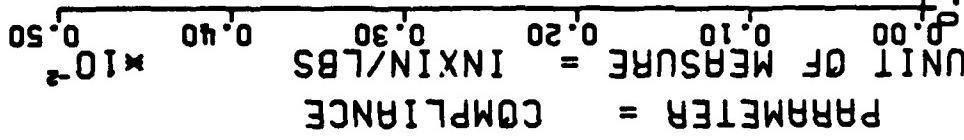
\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES
72.0	2
76.0	3
84.0	2
87.0	2
94.0	2
99.0	2
106.0	3
108.0	1
123.0	1
130.0	1
151.0	4
166.0	3
168.0	3
176.0	3
178.0	3
190.0	3
200.0	2
226.0	2

DISSECTED MOTOR TP-H1011.CREEP 10 LB LOAD.COMPLIANCE AT 10,000 SEC.

This sample size summary is applicable to figure 25

$\gamma = (( +3.5167596E-03 ) + ( -7.8579746E-06 ) * X) \times 10^{-2}$   
 $F = +2.1478094E+01$  SIGNIFICANCE OF F = SIGNIFICANT  
 $F = -6.0092372E-01$  SIGNIFICANCE OF F = SIGNIFICANT  
 $F = +4.634464E+00$  SIGNIFICANCE OF F = SIGNIFICANT  
 $N = 40$  DEGREES OF FREEDOM = 38  
 N = STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED MOTOR TP-H1011, CREEP 10 LB LOAD, COMPLIANCE AT 10,000 SEC.

Figure 25

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
72.0	2	190.0	3
76.0	3	200.0	3
84.0	2	226.0	4
87.0	2		
94.0	2		
99.0	2		
106.0	3		
108.0	1		
123.0	1		
130.0	1		
132.0	2		
134.0	2		
144.0	2		
146.0	2		
149.0	2		
151.0	2		
153.0	3		
157.0	2		
160.0	2		
166.0	3		
167.0	1		
168.0	6		
175.0	2		
176.0	3		
178.0	3		

DISSECTED MOTOR TF-H1011, CREEP 12 LB LOAD, COMPLIANCE AT 10 SEC.

This sample size summary is applicable to figures 26, 27 and 28

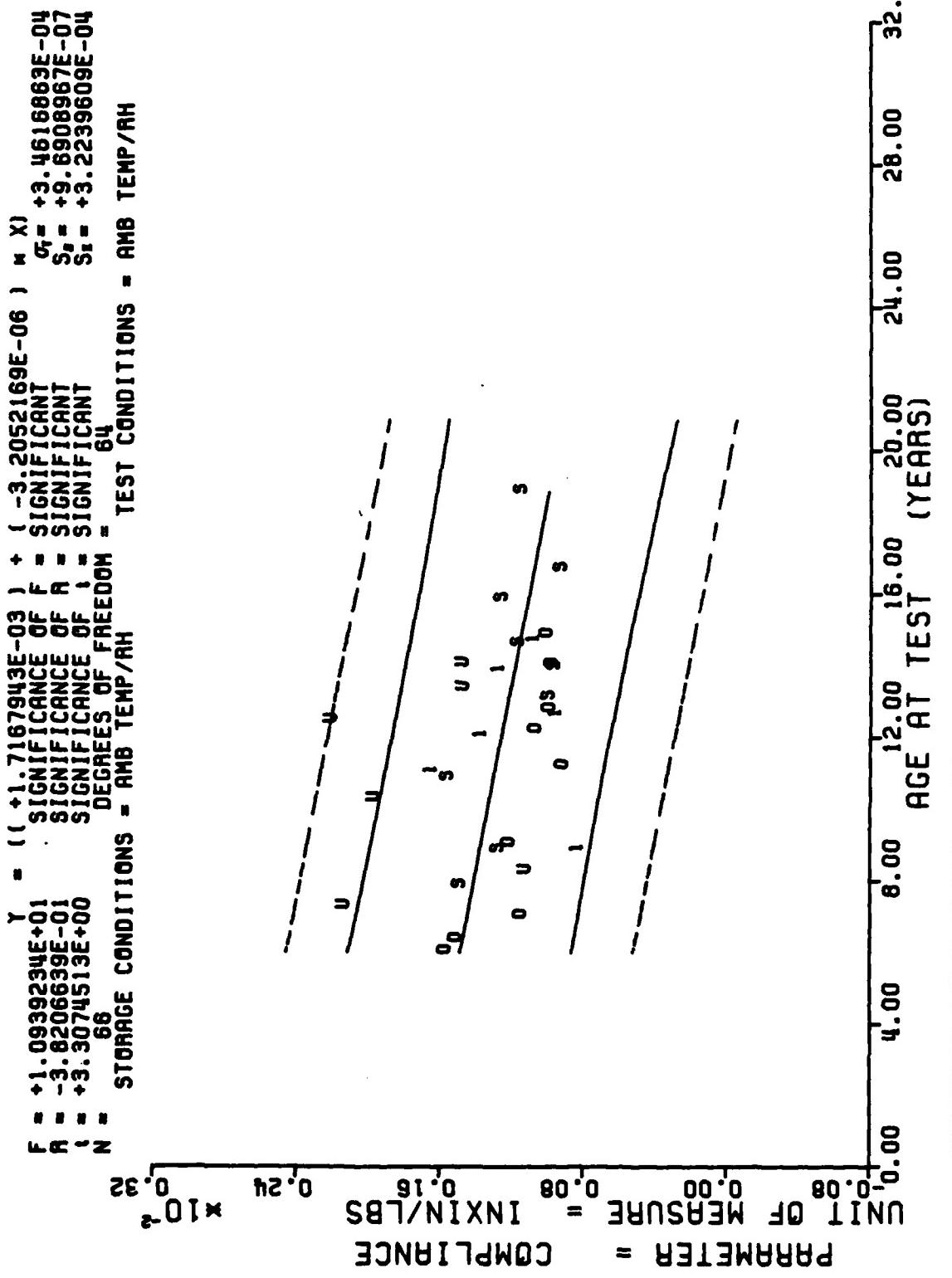
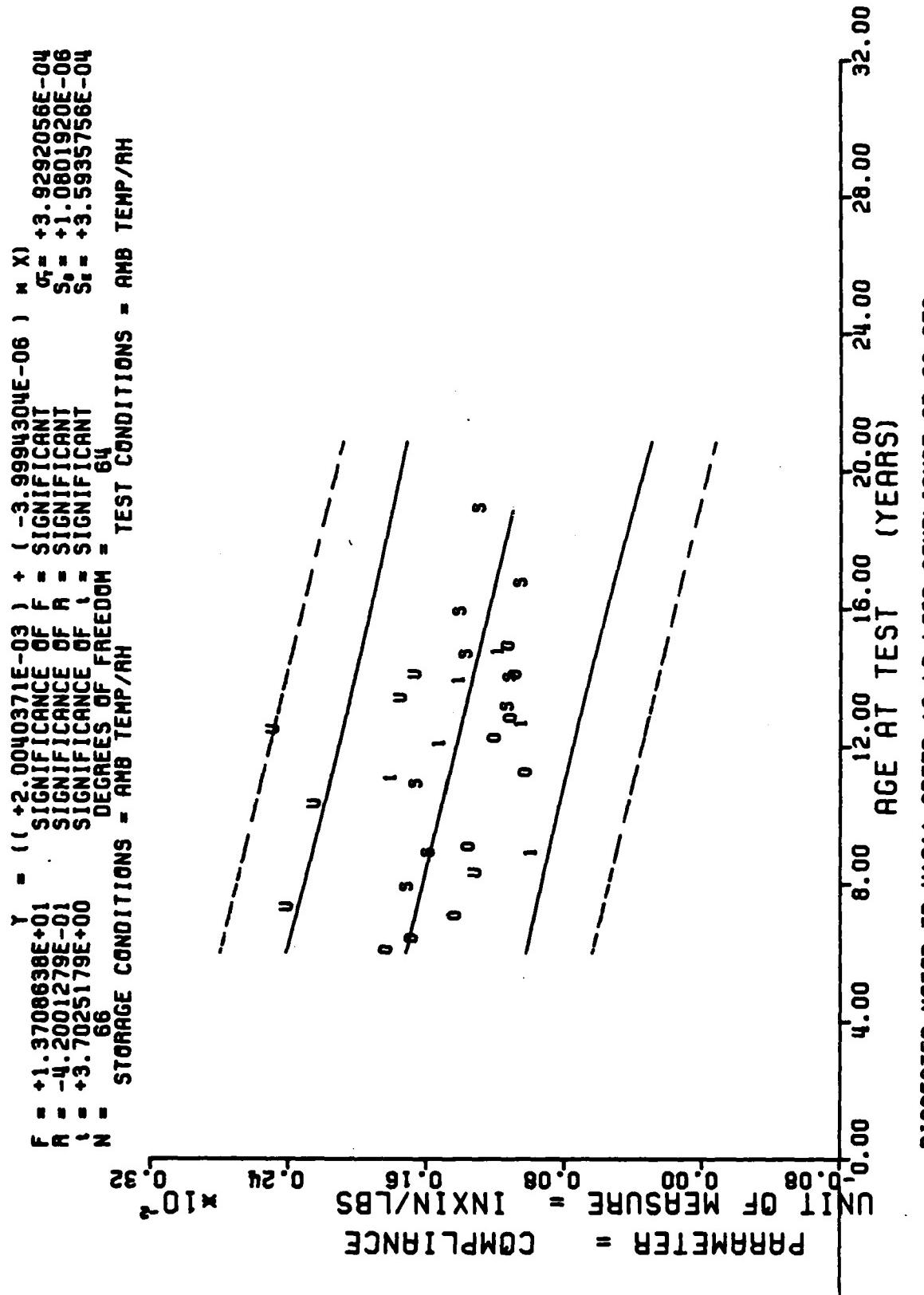


Figure 26



DISSECTED MOTOR TP-H1011, CREEP 12 LB LOAD, COMPLIANCE AT 20 SEC.

$\gamma = (( +3.0401620E-03) + (-5.0519635E-06) \times X)$   
 $F = +8.4940509E+00$  SIGNIFICANCE OF F = SIGNIFICANT  
 $F = -3.4712124E-01$  SIGNIFICANCE OF F = SIGNIFICANT  
 $F = +2.9144555E+00$  SIGNIFICANCE OF F = SIGNIFICANT  
 $N = 64$  DEGREES OF FREEDOM = 62  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

PARAMETER = COMPLIANCE  
 UNIT OF MEASURE = INCHIN/LBS  $\times 10^{-2}$   
 0.00 0.10 0.20 0.30 0.40 0.50

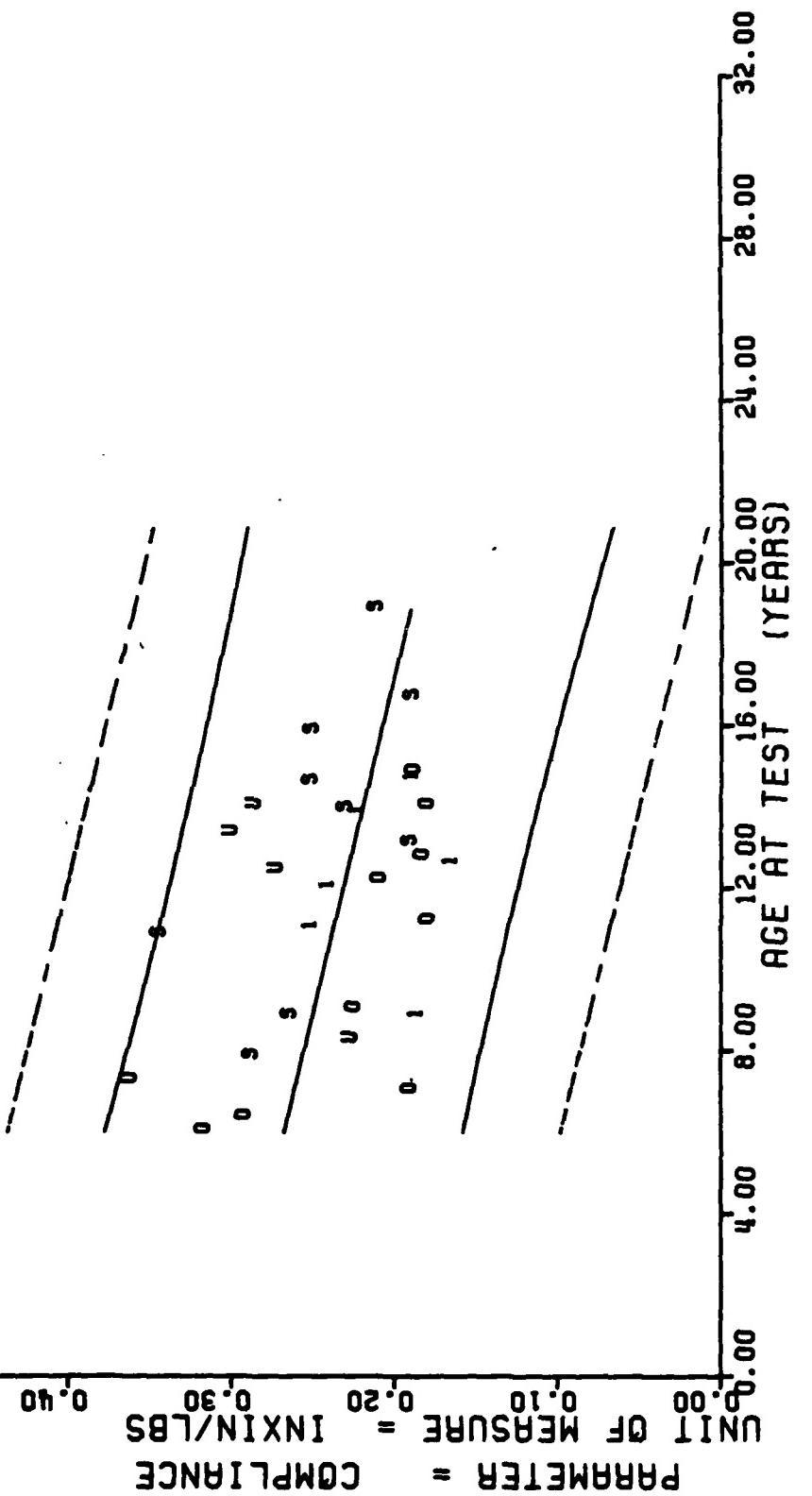


Figure 28

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

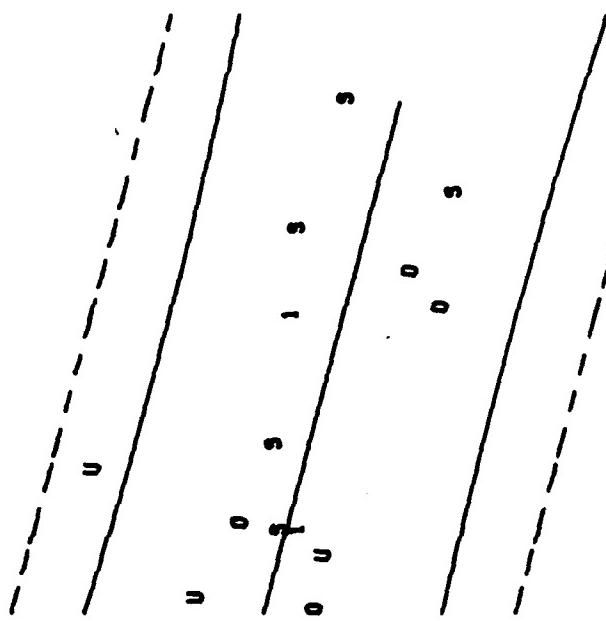
AGE (MONTHS)	NR SAMPLES
84.0	2
87.0	2
99.0	2
106.0	3
108.0	1
123.0	1
130.0	1
166.0	3
168.0	3
178.0	2
190.0	3
200.0	3
226.0	4

TP-H1011 DISSECTED MOTORS. CREEP. X STRAIN AT RUPTURE. 12 LB LCAD

This sample size summary is applicable to figure 29

$\gamma = 11.4251521E+00$   
 $\alpha = -2.5034808E+01$   
 $\beta = (-2.2198293E-02)$   
 $\sigma_1 = 2.1944967E+00$   
 $\sigma_2 = +2.1944967E+00$   
 $s_1 = +7.4303927E-03$   
 $s_2 = +1.9447903E+00$   
 $N = 30$   
 $F = +8.9251521E+00$   
 $\alpha = -4.9163939E-01$   
 $\beta = +2.9874993E+00$   
 $\sigma_1 = +2.9874993E+00$   
 $\sigma_2 = +2.9874993E+00$   
 $s_1 = +2.9874993E+00$   
 $s_2 = +2.9874993E+00$   
 $Degrees of Freedom = 28$   
 $Storage Conditions = A M B T E M P / R H$   
 $Test Conditions = A M B T H P / R H 12 L B$

PARAMETER = STRAIN  
 UNIT OF MEASURE = PERCENT  
 0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00 32.00  
 12.00 16.00 20.00 24.00 28.00 32.00



TP-H1011 DISSECTED MOTORS. CREEP. Z STRAIN AT RUPTURE. 12 LB LOAD

Figure 29

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
57.0	3	166.0	3
60.0	3	168.0	9
73.0	3	175.0	3
82.0	3	179.0	3
84.0	3	183.0	3
88.0	3	190.0	3
95.0	4	191.0	3
99.0	4	201.0	3
106.0	6	202.0	3
108.0	5	215.0	3
116.0	5	226.0	3
118.0	5		
123.0	5		
130.0	5		
132.0	5		
133.0	5		
134.0	5		
140.0	5		
144.0	5		
145.0	5		
150.0	5		
151.0	5		
153.0	5		
157.0	5		
160.0	5		

TP-H101 DISSECTED MTRS. STRESS RELAXATION MODULUS. 3 PERCENT STRAIN, 10 SEC

This sample size summary is applicable to figures 30 thru 33

$F = +2.8487511E+00$   
 $R = +1.5417377E-01$   
 $I = +1.6878243E+00$   
 $N = 119$   
 $\gamma = (( +6.0574963E+02 ) + ( +5.3679689E-01 ) * X)$   
 SIGNIFICANCE OF  $F$  = NOT SIGNIFICANT  
 SIGNIFICANCE OF  $R$  = NOT SIGNIFICANT  
 SIGNIFICANCE OF  $I$  = NOT SIGNIFICANT  
 DEGREES OF FREEDOM = 117

STORAGE CONDITIONS = AMB TEMP/RH

PARAMETER = STRESS RELAX MODULUS

UNIT OF MEASURE = PSI

TP-H1011 DISSECTED MTRS. STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 10 SEC

Figure 30

$F = +1.7196930E+00$   
 $R = +1.2035498E-01$   
 $t = +1.3113706E+00$   
 $N = 119$   
 $\gamma = (+4.7690389E+02) \times (+3.3943939E-01) \times X$   
 $F = \text{NOT SIGNIFICANT}$   
 $R = \text{NOT SIGNIFICANT}$   
 $t = \text{NOT SIGNIFICANT}$   
 $Degrees of Freedom = 117$   
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

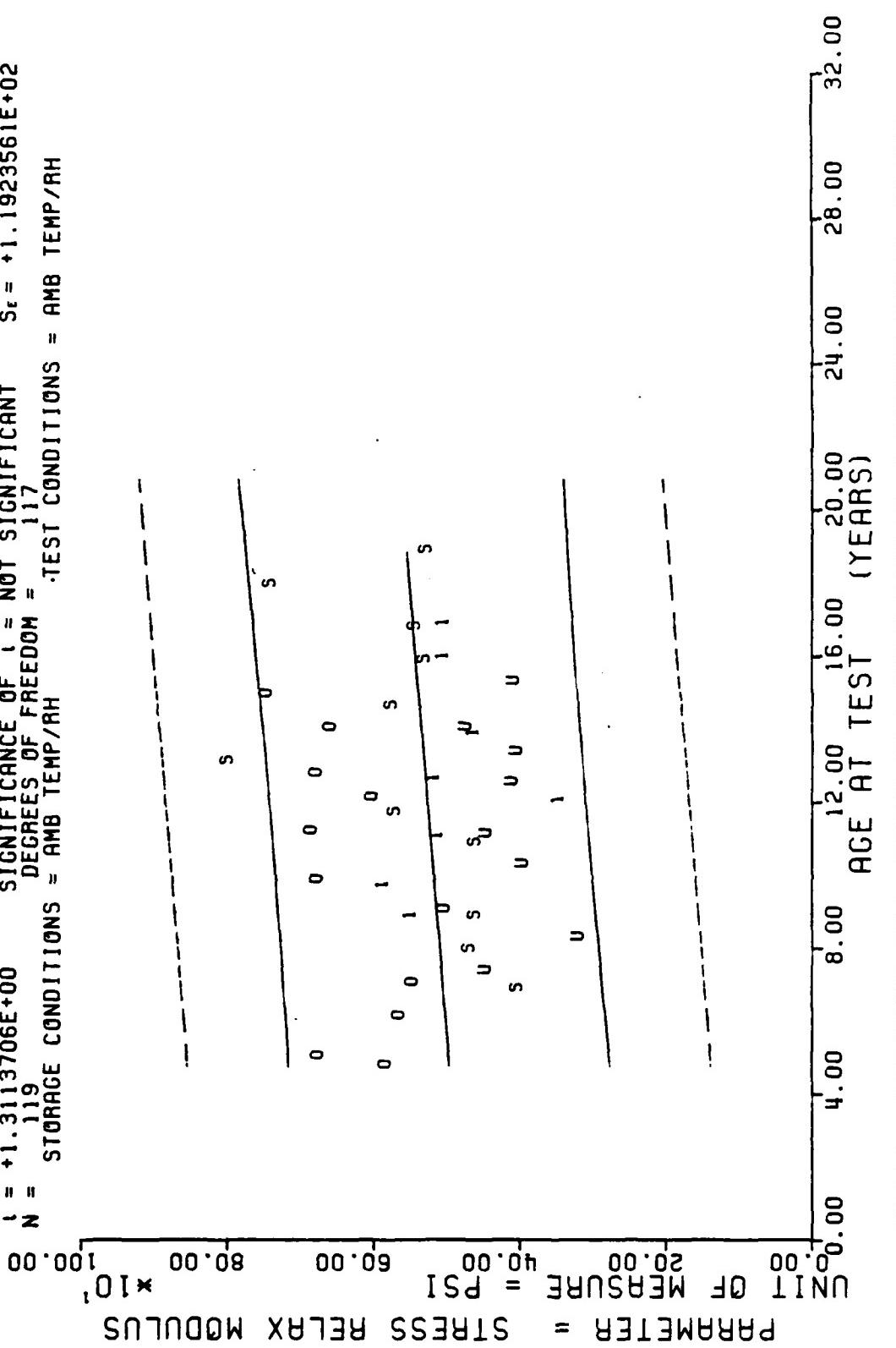
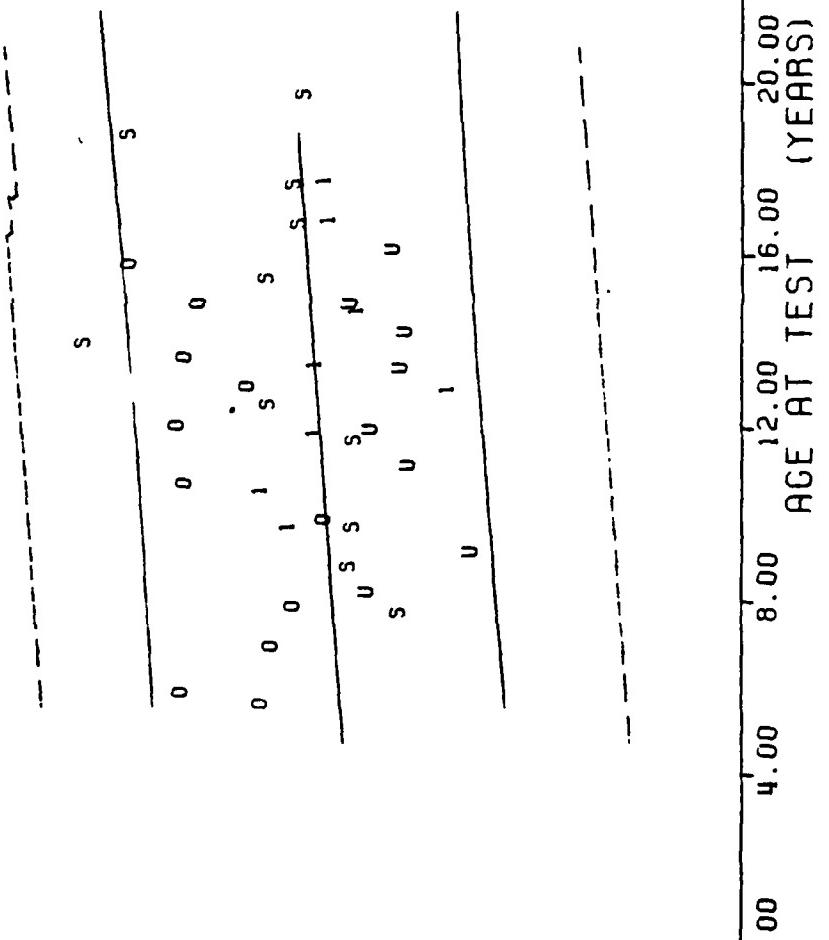


Figure 31

$F = +1.6311179E+00$   
 $R = +1.1725824E-01$   
 $t = +1.2771522E+00$   
 $N = 119$   
 $\gamma = +4.4359145E+02$   
 $F = \text{NOT SIGNIFICANT}$   
 $R = \text{NOT SIGNIFICANT}$   
 $t = \text{NOT SIGNIFICANT}$   
 $Degrees of Freedom = 117$   
 $Storage Conditions = AMB TEMP/RH$

PARAMETER = STRESS RELAX MODULUS

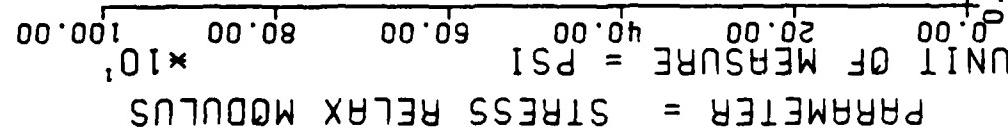
UNIT OF MEASURE = PSI  $\times 10^3$



TP-H1011 DISSECTED MTRS. STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 100 SEC

Figure 32

$F = +8.0933501E-01$   
 $R = +8.39960605E-02$   
 $L = +8.9963048E-01$   
 $N = 116$   
 Y = .1( +3.6038770E+02 ) + ( +1.8707721E-01 ) \* X  
 SIGNIFICANCE OF F = NOT SIGNIFICANT  
 SIGNIFICANCE OF R = NOT SIGNIFICANT  
 SIGNIFICANCE OF L = NOT SIGNIFICANT  
 DEGREES OF FREEDOM = 114  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



TP-H1011 DISSECTED MTRS. STRESS RELAXATION MODULUS, 3 PERCENT STRAIN, 1000 SEC

Figure 33

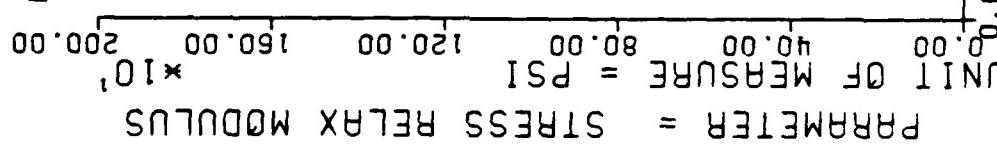
\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
57.0	5	166.0	5
60.0	3	168.0	9
73.0	3	175.0	5
82.0	3	179.0	5
84.0	3	183.0	5
88.0	3	190.0	5
95.0	4	191.0	5
99.0	3	201.0	5
106.0	6	202.0	5
108.0	3	215.0	5
116.0	3	226.0	5
118.0	3		
123.0	3		
130.0	3		
132.0	3		
133.0	3		
134.0	3		
140.0	3		
143.0	3		
145.0	3		
150.0	3		
151.0	3		
153.0	3		
157.0	3		
160.0	3		

TP-H1011 DISSECTED MTRs. STRESS RELAXATION MODULUS. 5 PERCENT STRAIN. 10 SEC

This sample size summary is applicable to figures 34 thru 37

$F = +4.8012925E+00$        $\gamma = +1(+6.3182583E+02)$        $(+7.2121983E-01) * X$   
 $F = \text{SIGNIFICANT}$        $F = \text{SIGNIFICANT}$        $G_t = +1.5405052E+02$   
 $R = +1.9936241E-01$        $R = \text{SIGNIFICANT}$        $S_b = +3.2914599E-01$   
 $\sigma = +2.1911851E+00$        $R = \text{SIGNIFICANT}$        $S_c = +1.5160737E+02$   
 $N = 118$        $\text{DEGREES OF FREEDOM} = 116$       TEST CONDITIONS = AMB TEMP/RH

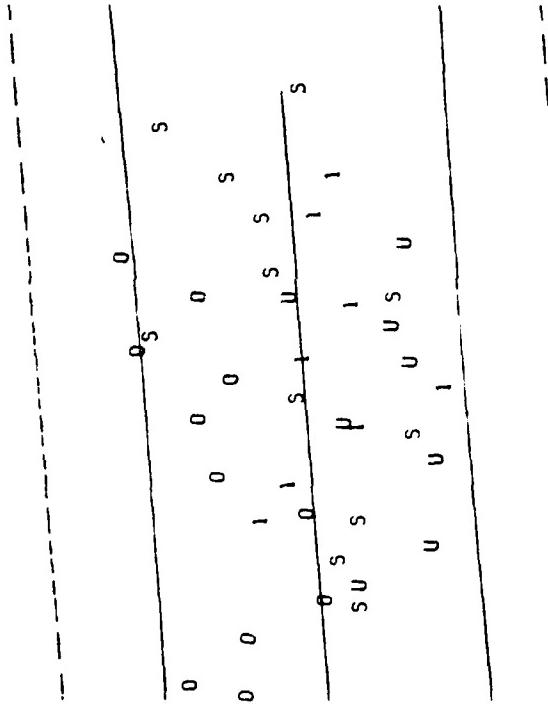


TP-H1011 DISSECTED MIRS. STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 10 SEC

Figure 34

$\gamma = (( +4.8205328E+02) + ( +3.2625377E-01) * X)$   
 $F = +2.1543623E+00$  SIGNIFICANCE OF F = NOT SIGNIFICANT  $\sigma_t = +1.0288684E+02$   
 $R = +1.3503131E-01$  SIGNIFICANCE OF R = NOT SIGNIFICANT  $S_0 = +2.2227783E-01$   
 $\alpha = +1.4677746E+00$  SIGNIFICANCE OF  $\alpha$  = NOT SIGNIFICANT  $S_t = +1.0238301E+02$   
 $N = 118$  DEGREES OF FREEDOM = 116 TEST CONDITIONS = AMB TEMP/RH

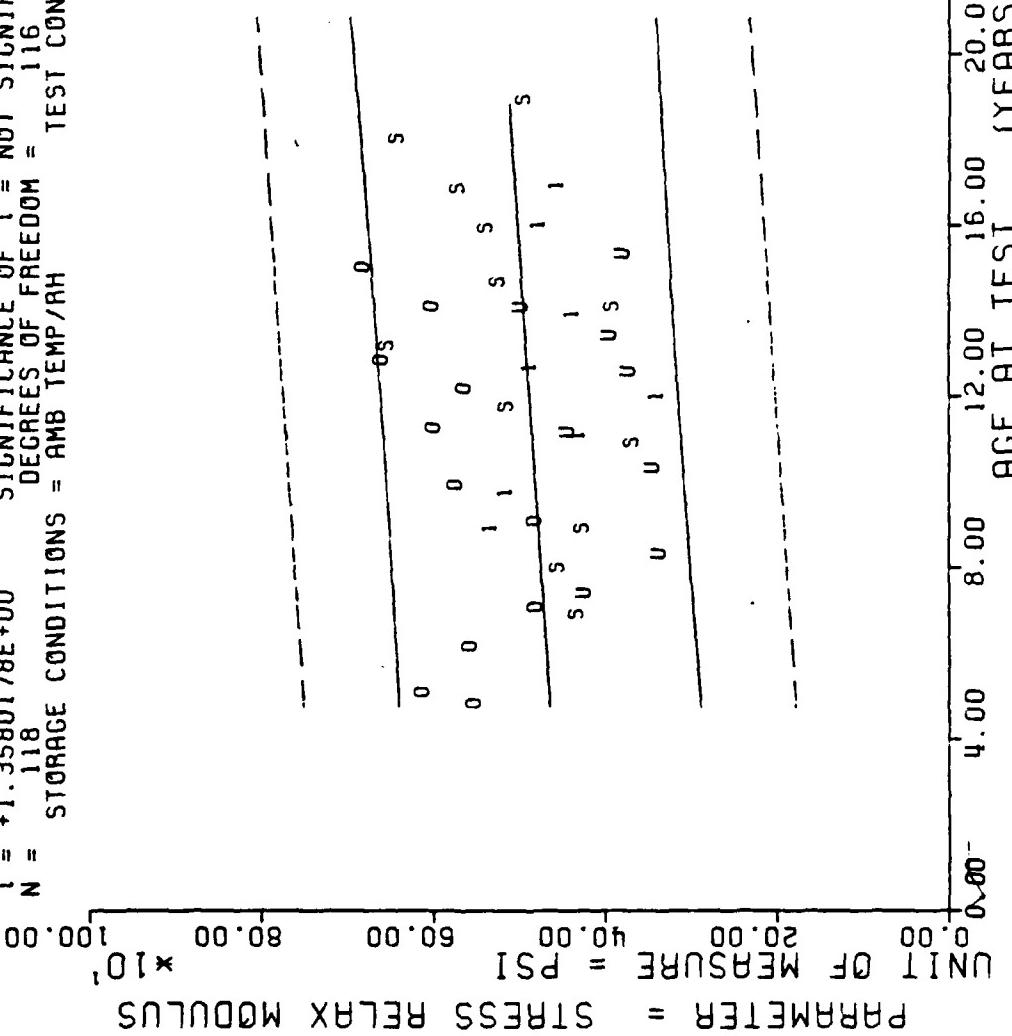
PARAMETER = STRESS RELAX MODULUS  
 UNIT OF MEASURE = PSI  
 0.00 20.00 40.00 60.00 80.00 100.00 \*10



TP-H1011 DISSECTED MTRs, STRESS RELAXATION MODULUS, S PERCENT STRAIN, 50 SEC  
 0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00 32.00

Figure 35

$F = +1.8442126E+00$        $\gamma = .1( +4.4807846E+02 ) + ( +2.8140082E-01 ) * X$   
 SIGNIFICANCE OF F = NOT SIGNIFICANT       $\sigma_r = +9.5788380E+01$   
 $R = +1.2509828E-01$       F = NOT SIGNIFICANT  
 $\epsilon = +1.3580178E+00$       R = NOT SIGNIFICANT  
 $N = 118$       DEGREES OF FREEDOM = 116  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH



TP-H1011 DISSECTED MTRS. STRESS RELAXATION MODULUS. 5 PERCENT STRAIN, 100 SEC

Figure 36

$F = +1.1986055E+00$        $\gamma = (( +3.5864634E+02 ) + ( +1.9436482E-01 ) * X)$   
 $R = +1.0244900E-01$       SIGNIFICANCE OF F = NOT SIGNIFICANT       $\sigma_r = +7.7646471E+01$   
 $I = +1.0948084E+00$       SIGNIFICANCE OF R = NOT SIGNIFICANT       $S_b = +1.7753317E-01$   
 $N = 115$       SIGNIFICANCE OF I = NOT SIGNIFICANT       $S_f = +7.7578923E+01$   
DEGREES OF FREEDOM = 113      TEST CONDITIONS = AMB TEMP/RH

PARAMETER = STRESS RELAX MODULUS  
UNIT OF MEASURE = PSI       $* 10^3$   
0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00 32.00

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TP-H1011 DISSECTED MTRS, STRESS RELAXATION MODULUS, 5 PERCENT STRAIN, 1000 SEC

Figure 37

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

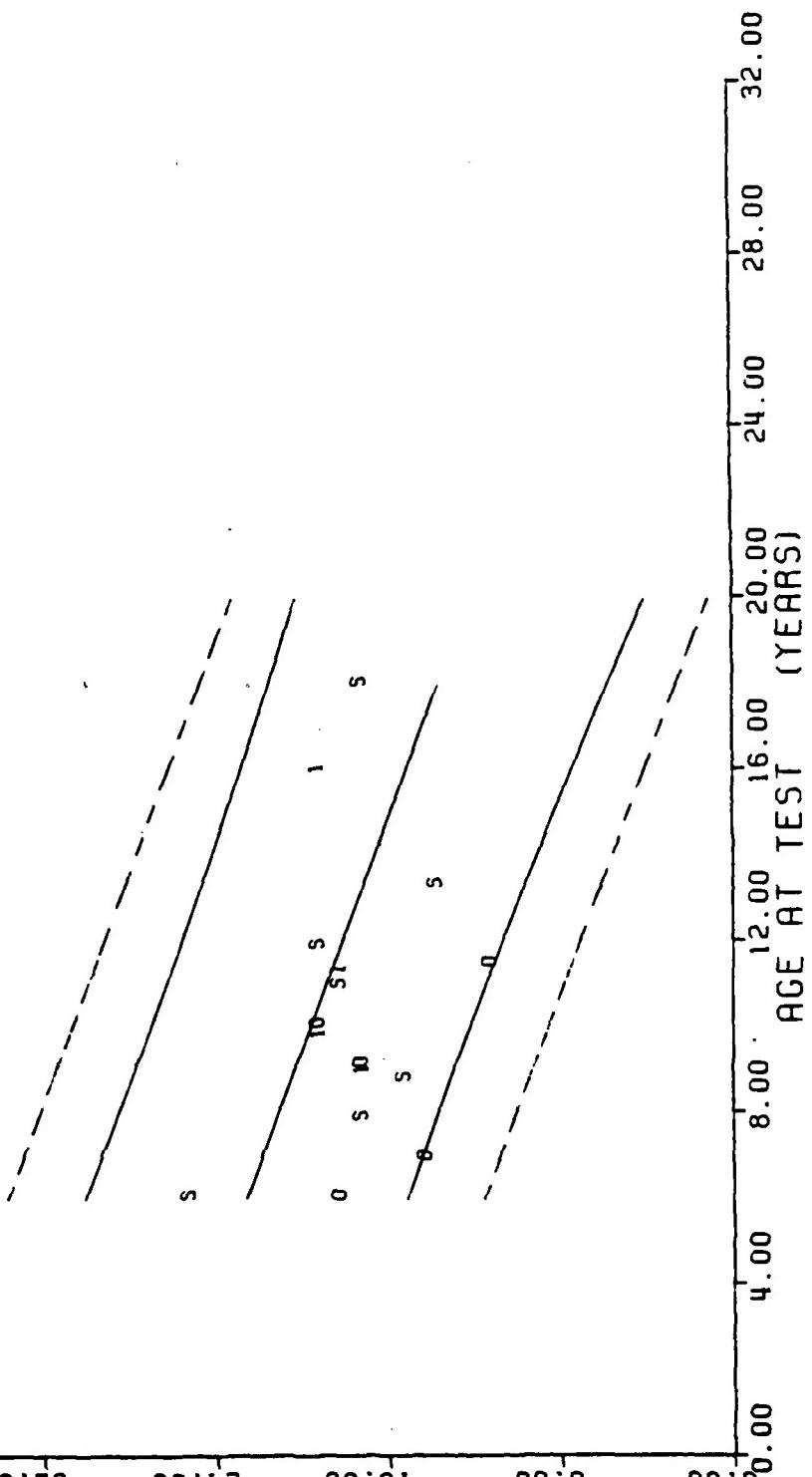
AGE (MONTHS)	N <sub>F</sub> SAMPLES
72.0	16
83.0	1
94.0	1
105.0	1
107.0	1
109.0	1
117.0	1
120.0	1
131.0	1
135.0	2
137.0	2
142.0	1
159.0	2
191.0	2
215.0	2

STAGE 1 DISC10 M10S. CONSTANT STRAIN. STRAIN 0.1 INIT AND 0.01 EVERY 48 HRS

This sample size summary is applicable to figure 38

$\gamma = .1( +2.7087033E+01) + (-6.2517465E-02) * X$   
 $F = +2.2775769E+01$  SIGNIFICANCE OF  $F$  = SIGNIFICANT  
 $R = -6.3336639E-01$  SIGNIFICANCE OF  $R$  = SIGNIFICANT  
 $I = +4.7723966E+00$  SIGNIFICANCE OF  $I$  = SIGNIFICANT  
 $N = 36$  DEGREES OF FREEDOM = 34  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

PARAMETER = STRAIN AT RUPTURE  
 UNIT OF MEASURE = PERCENT  
 0.00 8.00 16.00 24.00 32.00 40.00



STAGE 1 OSSCTD MTRS. CONSTANT STRAIN, STRAIN 0.1 INIT AND 0.01 EVERY 48 HRS

Figure 38

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

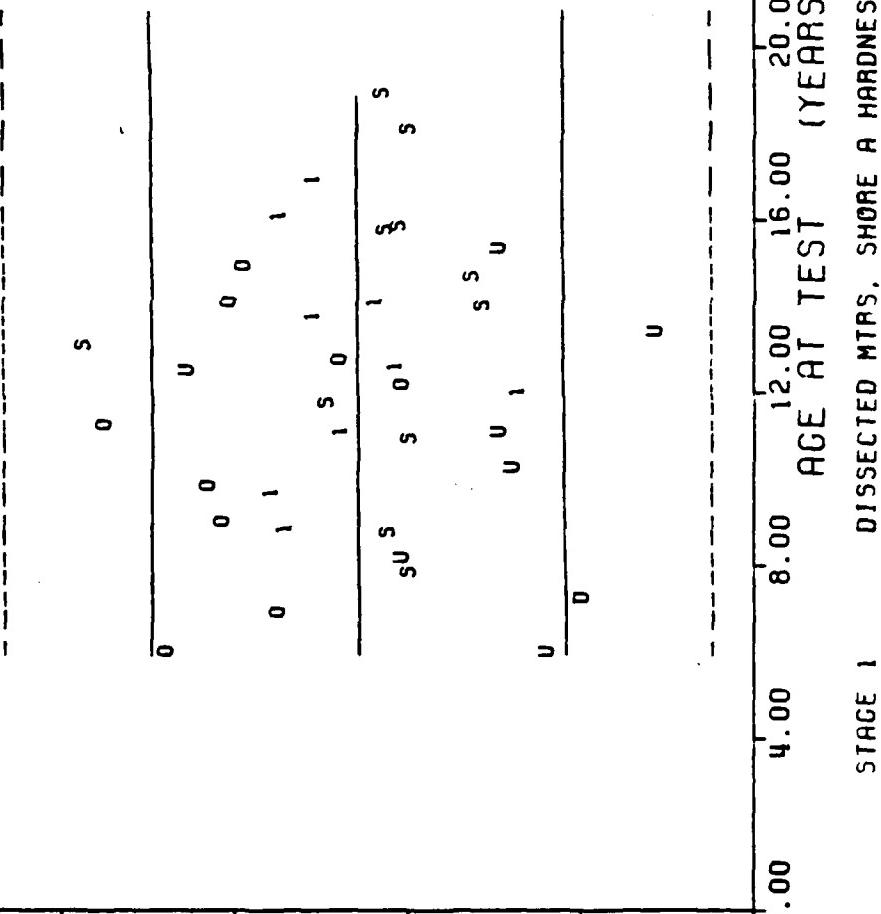
AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
71.0	6	175.0	5
82.0	5	178.0	10
86.0	6	183.0	10
93.0	1	186.0	10
97.0	5	189.0	10
104.0	5	192.0	50
105.0	6	202.0	10
107.0	5	216.0	50
115.0	5	226.0	10
117.0	5		
122.0	5		
130.0	5		
122.0	10		
134.0	5		
140.0	5		
143.0	3		
145.0	3		
149.0	5		
150.0	5		
152.0	5		
156.0	5		
160.0	5		
164.0	10		
167.0	3		
168.0	20		

STAGE 1 CISSECTED MTRS. SHORE A HAPDNESS, 10 SECOND

This sample size summary is applicable to figure 39

$\gamma = (( +6.6344922E+01) + (+6.8433347E-04) * X)$   
 $F = \text{SIGNIFICANCE OF } F = \text{NOT SIGNIFICANT}$   
 $R = \text{SIGNIFICANCE OF } R = \text{NOT SIGNIFICANT}$   
 $L = \text{SIGNIFICANCE OF } L = \text{NOT SIGNIFICANT}$   
 $N = 305$   
 $\text{DEGREES OF FREEDOM} = 303$   
 $\text{STORAGE CONDITIONS} = \text{AMB TEMP/RH}$

UNIT OF MEASURE = SHORE A  
 PARAMETER = 10 SECOND HARDNESS  
 0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00 32.00



STAGE 1 DISSECTED MTRS. SHORE A HARDNESS, 10 SECOND

Figure 39

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	N <sub>R</sub> SAMPLES
71.0	3
83.0	2
93.0	1
105.0	2
108.0	2
111.0	2
127.0	2
129.0	2
133.0	2
135.0	3
137.0	2
151.0	2
152.0	2
153.0	2
155.0	2
169.0	1
170.0	2
175.0	1
176.0	1
178.0	2
180.0	1
202.0	2

STAGE I DISSECTED MOTCRS, DYNAMIC RESPONSE, CENTER-WI 70 GM, STCR SHEAR AT 200 HZ

This sample size summary is applicable to figures 40 thru 43

$F = +1.5183324E+00$        $\gamma = (( +5.6207916E-01 ) + ( +2.4108331E-04 ) * X)$   
 SIGNIFICANCE OF  $F =$  NOT SIGNIFICANT       $\sigma_f = +4.3338176E-02$   
 $R = +1.9357873E-01$       SIGNIFICANCE OF  $R =$  NOT SIGNIFICANT       $S_0 = +1.9565174E-04$   
 $\epsilon = +1.2322063E+00$       SIGNIFICANCE OF  $\epsilon =$  NOT SIGNIFICANT       $S_\epsilon = +4.3060081E-02$   
 $N = 41$       DEGREES OF FREEDOM = 39  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

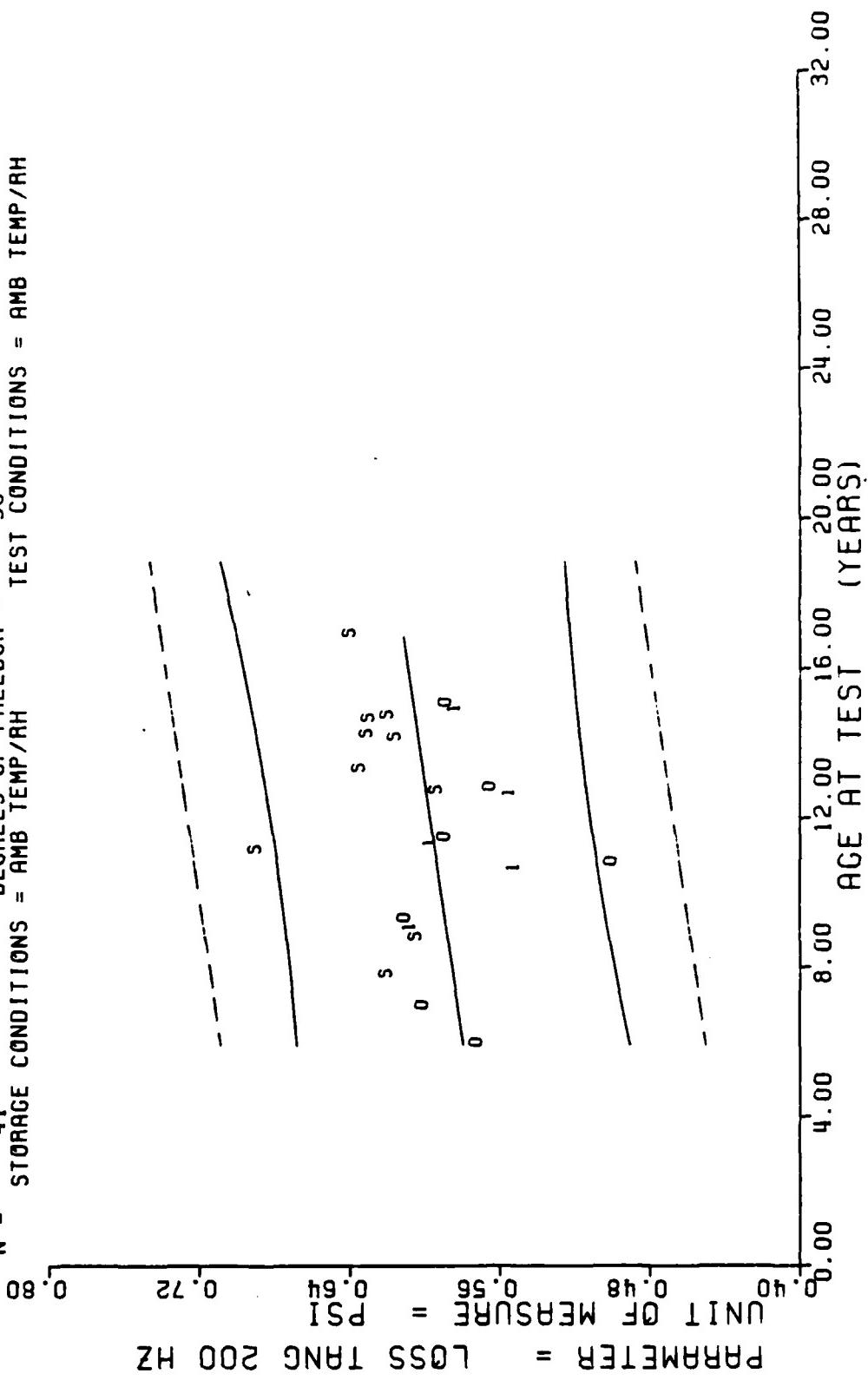
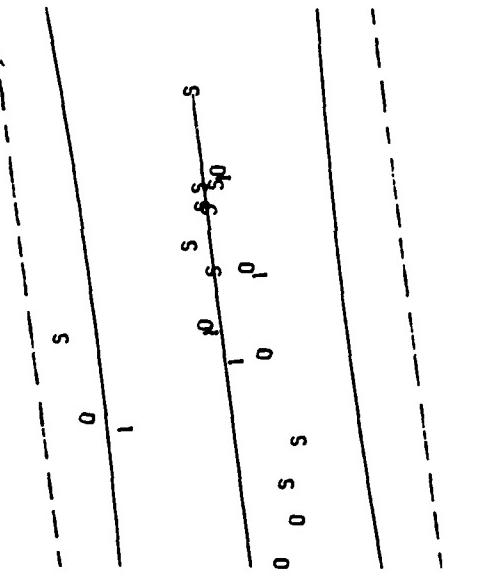


Figure 40

$F = +2.4992484E+00$        $Y = (( +5.9568513E-01 ) + ( +5.2736034E-04 ) * X)$   
 $R = +2.4540567E-01$       SIGNIFICANCE OF F = NOT SIGNIFICANT       $\sigma_r = +7.4779749E-02$   
 $I = +1.5809011E+00$       SIGNIFICANCE OF R = NOT SIGNIFICANT       $S_o = +3.3358211E-04$   
 $N = 41$       DEGREES OF FREEDOM = 39      TEST CONDITIONS = AMB TEMP/RH

PARAMETER = LOSS TANG 400 Hz  
 UNIT OF MEASURE = PSI  
 0.00 0.20 0.40 0.60 0.80 1.00 1.20



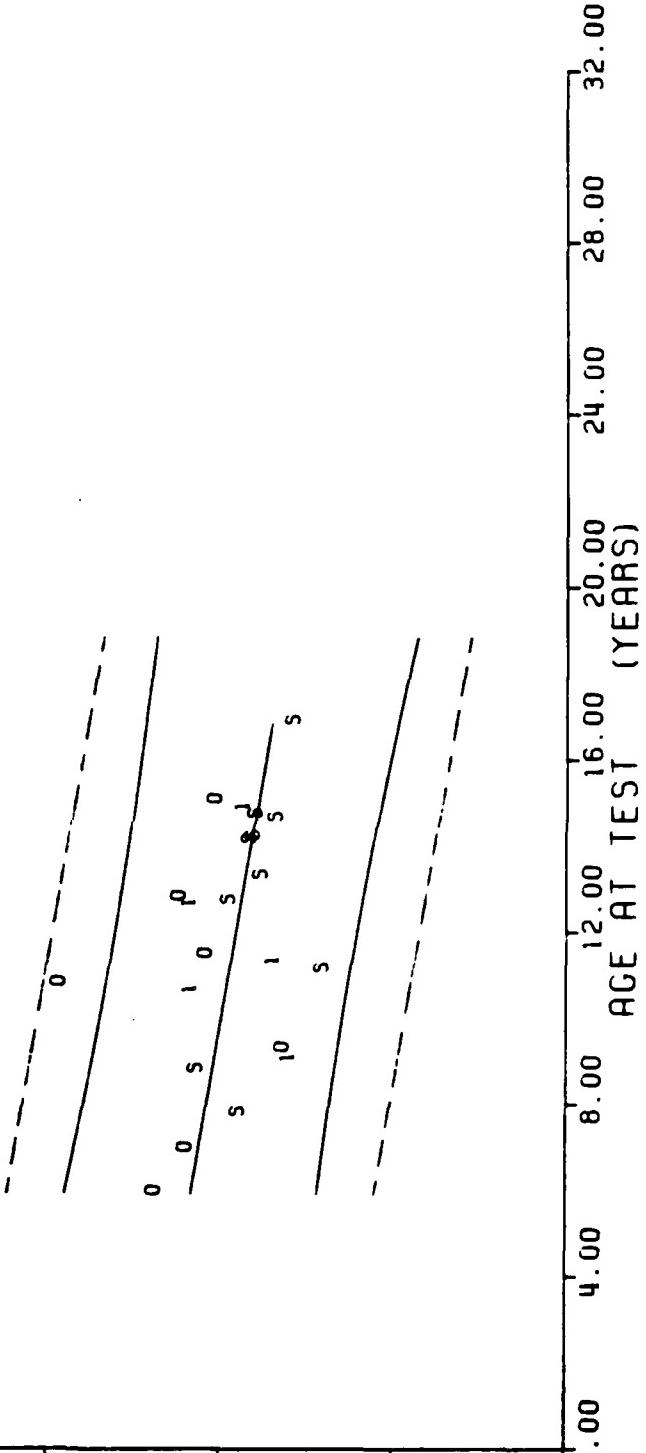
STAGE 1 DISSECTED MOTORS, DYNAMIC RESPONSE, CENTER-MT 70 GM, LOSS TANG AT 400 Hz  
 0.00 4.00 8.00 12.00 16.00 20.00 24.00 28.00 32.00

STAGE 1 DISSECTED MOTORS, DYNAMIC RESPONSE, CENTER-MT 70 GM, LOSS TANG AT 400 Hz

Figure 41

$\gamma = (( +4.8408579E+03) + (-7.1612581E+00) * X)$   
 $F = +4.9658665E+00$  SIGNIFICANCE OF F = SIGNIFICANT       $\sigma_t = +7.4149932E+02$   
 $R = -3.3607770E-01$  SIGNIFICANCE OF R = SIGNIFICANT       $S_t = +3.2135999E+00$   
 $t = +2.2284224E+00$  SIGNIFICANCE OF t = SIGNIFICANT       $S_e = +7.0726625E+02$   
 $N = 41$  DEGREES OF FREEDOM = 39  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

UNIT OF MEASURE = PSI      20.00 40.00 60.00 80.00  $\times 10^2$   
 PARAMETER = STOR SHEAR 200 Hz      20.00 40.00 80.00 120.00 160.00 200.00 240.00 280.00 320.00



STAGE 1 DISSECTED MOTORS. DYNAMIC RESPONSE. CENTER-WT 70 GM. STOR SHEAR AT 200 Hz

Figure 42

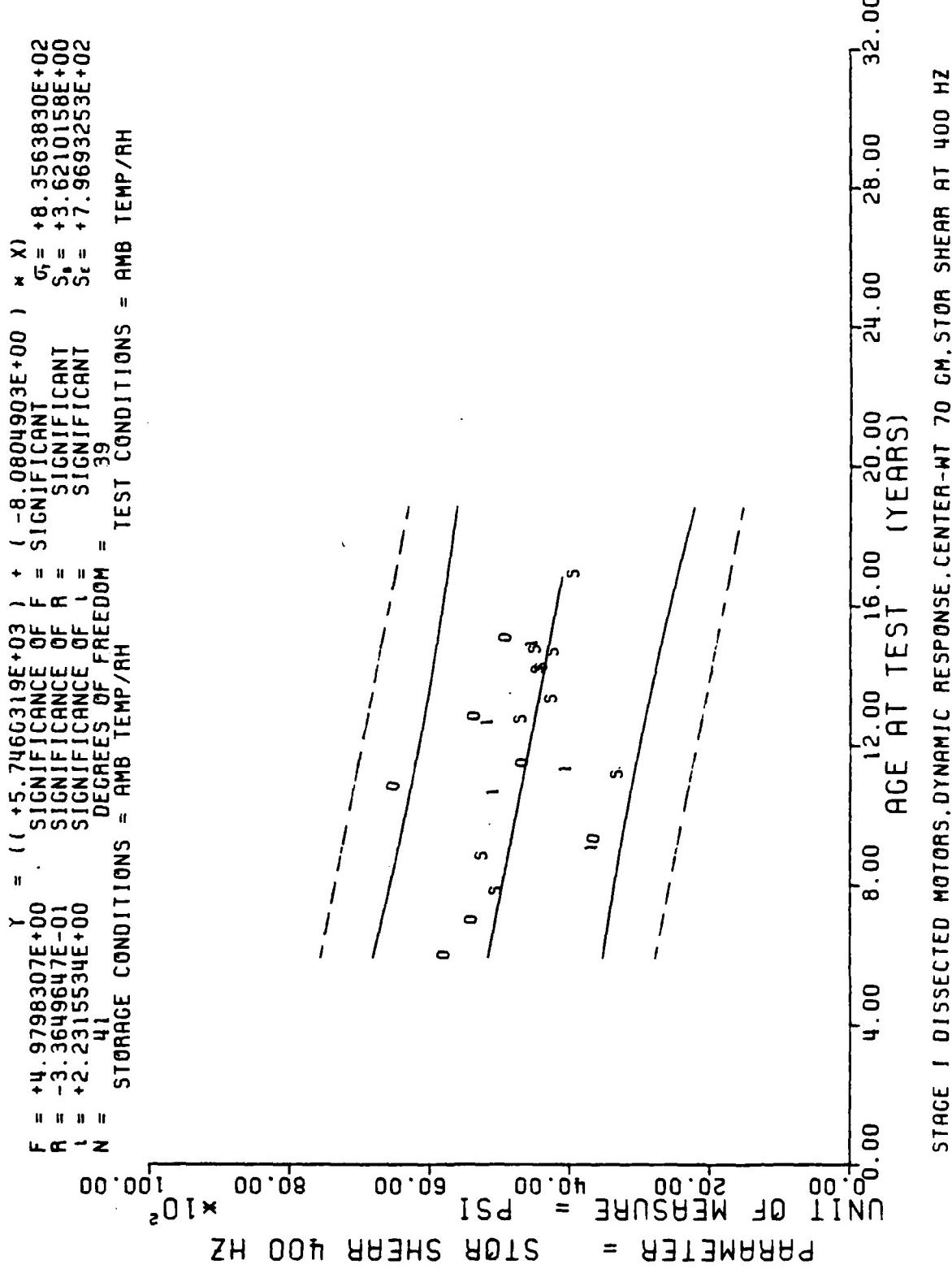


Figure 43

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	N <sub>F</sub> SAMPLES
151.0	18
160.0	11
177.0	8
191.0	6
192.0	11
201.0	9
202.0	10
216.0	9
227.0	16

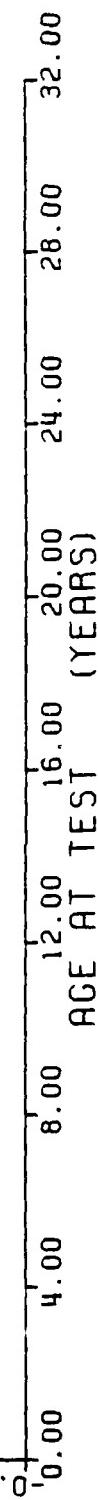
STAGE I DISSECTEC MOTORS. TEAR ENERGY TEST/TEMP=77 DEG F

This sample size summary is applicable to figure 44

$F = +2.9796631E-02$   
 $R = -1.7259129E-02$   
 $I = +1.7261700E-01$   
 $N = 102$   
 $Y = \left( \left( +1.2918318E+00 \right) + \left( -3.0759457E-04 \right) * X_1 \right)$   
 $\text{STORAGE CONDITIONS} = \text{AMB TEMP/RH}$   
 $\text{DEGREES OF FREEDOM} = 100$   
 $\text{TEST CONDITIONS} = 77 \text{ DEG/F AMB-RH}$   
 $F = \text{NOT SIGNIFICANT}$   
 $R = \text{NOT SIGNIFICANT}$   
 $I = \text{NOT SIGNIFICANT}$   
 $N = 102$

$\text{PARAMETER} = \text{COHESIVE ENERGY}$   
 $\text{UNIT OF MEASURE} = \text{IN-LB/INXIN}$   
 $0.00 \quad 0.80 \quad 1.60 \quad 2.40 \quad 3.20$

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STAGE 1 DISSECTED MOTORS. TEAR ENERGY TEST/TEMP=77 DEG F

Figure 44

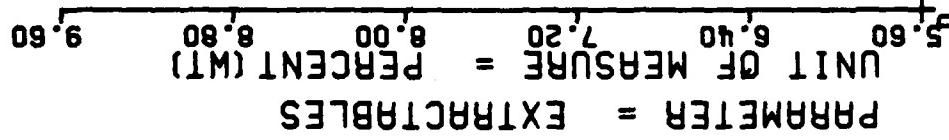
\* \* \* SAMPLE SIZE SUMMARY \* \* \*

AGE (MONTHS)	N.F. SAMPLES
133.0	4
135.0	4
146.0	4
148.0	4
150.0	4
152.0	4
154.0	4
157.0	4
163.0	4
167.0	6
169.0	4
170.0	4
176.0	4
184.0	6
191.0	6
193.0	6
217.0	6

DISSECTED MTR, STAGE 1, TF-H1011, SCL GEL, PERCENT EXTRACTABLES

This sample size summary is applicable to figures 45 thru 48

$\gamma = ((+7.3834963E+00) + (-1.8846172E-03) \times X)$   
 $F = +9.7903503E-01$  SIGNIFICANCE OF F = NOT SIGNIFICANT  
 $R = -1.1277501E-01$  SIGNIFICANCE OF R = NOT SIGNIFICANT  
 $R^2 = +9.8946199E-01$  SIGNIFICANCE OF  $R^2$  = NOT SIGNIFICANT  
 $N = 78$  DEGREES OF FREEDOM = 76  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH



DISSECTED MTR. STAGE I. TP-H1011. SOL GEL. PERCENT EXTRACTABLES

Figure 45

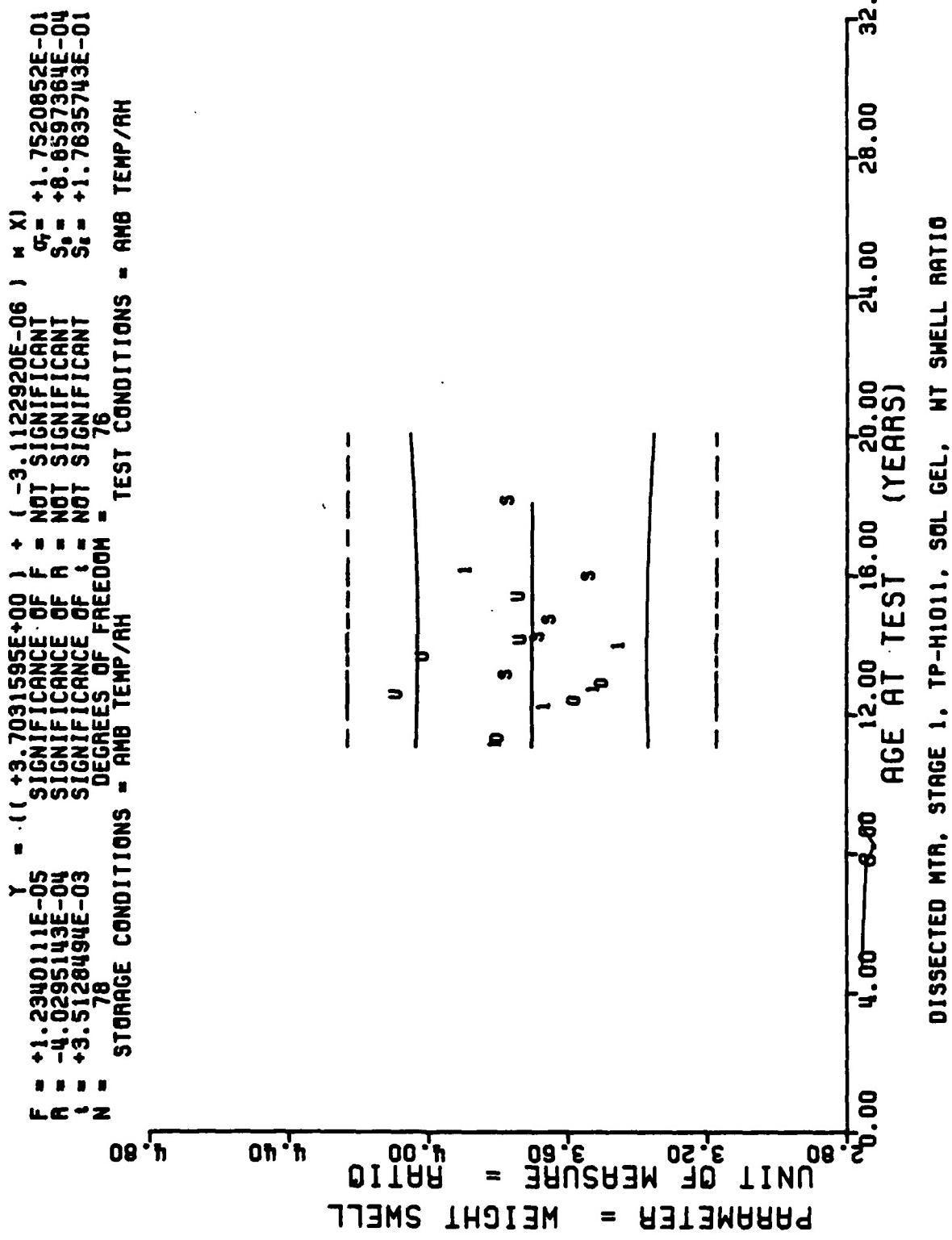
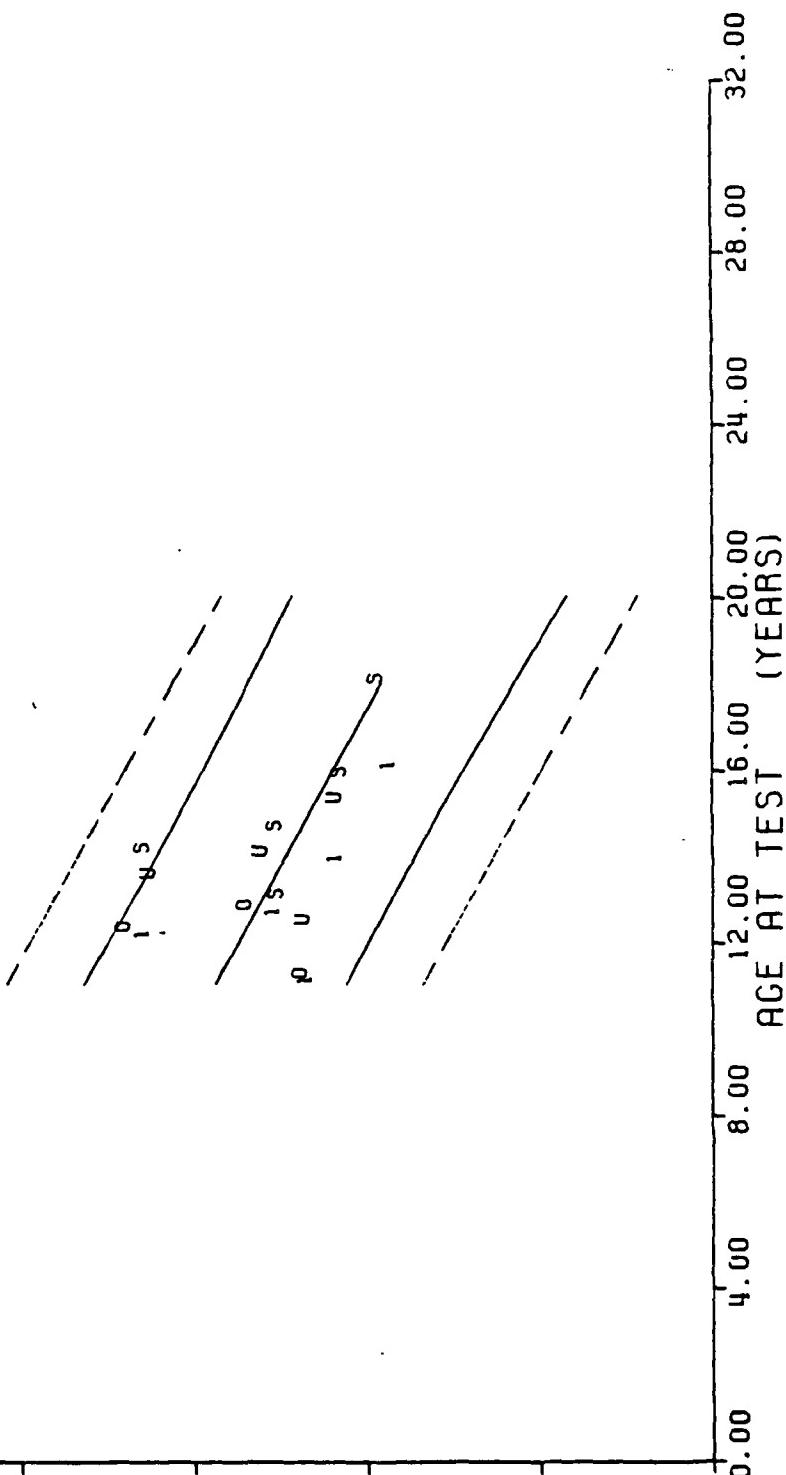


Figure 46

$\gamma = ((+1.8080676E+00) + (-2.2965368E-04) * X)$   
 $F = \text{SIGNIFICANCE OF } F = \text{SIGNIFICANT}$   
 $R = \text{SIGNIFICANCE OF } R = \text{SIGNIFICANT}$   
 $L = \text{SIGNIFICANCE OF } L = \text{SIGNIFICANT}$   
 $D = \text{DEGREES OF FREEDOM} = 76$   
 $N = \text{STORAGE CONDITIONS} = \text{AMB TEMP/RH}$

PARAMETER = DENSITY  
 UNIT OF MEASURE = GRAMS/CC  
 1.72 1.74 1.76 1.78 1.80



DISSECTED MTR, STAGE 1, TP-H1011, SOL GEL, DENSITY

Figure 47

$F = +8.2429841E+00$        $\gamma = (( +1.3899121E-02 ) + ( -2.0379311E-05 ) \times X)$   
 $R = -2.7551591E-01$        $F = \text{SIGNIFICANT}$   
 $S = +2.4985984E+00$        $R = \text{SIGNIFICANT}$   
 $N = 78$        $S = +8.1563038E-08$   
 $D = 76$        $S = +1.6235525E-03$   
 DEGREES OF FREEDOM = TEST CONDITIONS = AMB TEMP/RH

STORAGE CONDITIONS = AMB TEMP/RH

PARAMETER = CROSSSLINK DENSITY  
 UNIT OF MEASURE = MILLIEAV/C.C.  
 $0.04 \quad 0.08 \quad 0.12 \quad 0.16 \quad 0.20 \quad 0.24 \quad \times 10^{-3}$

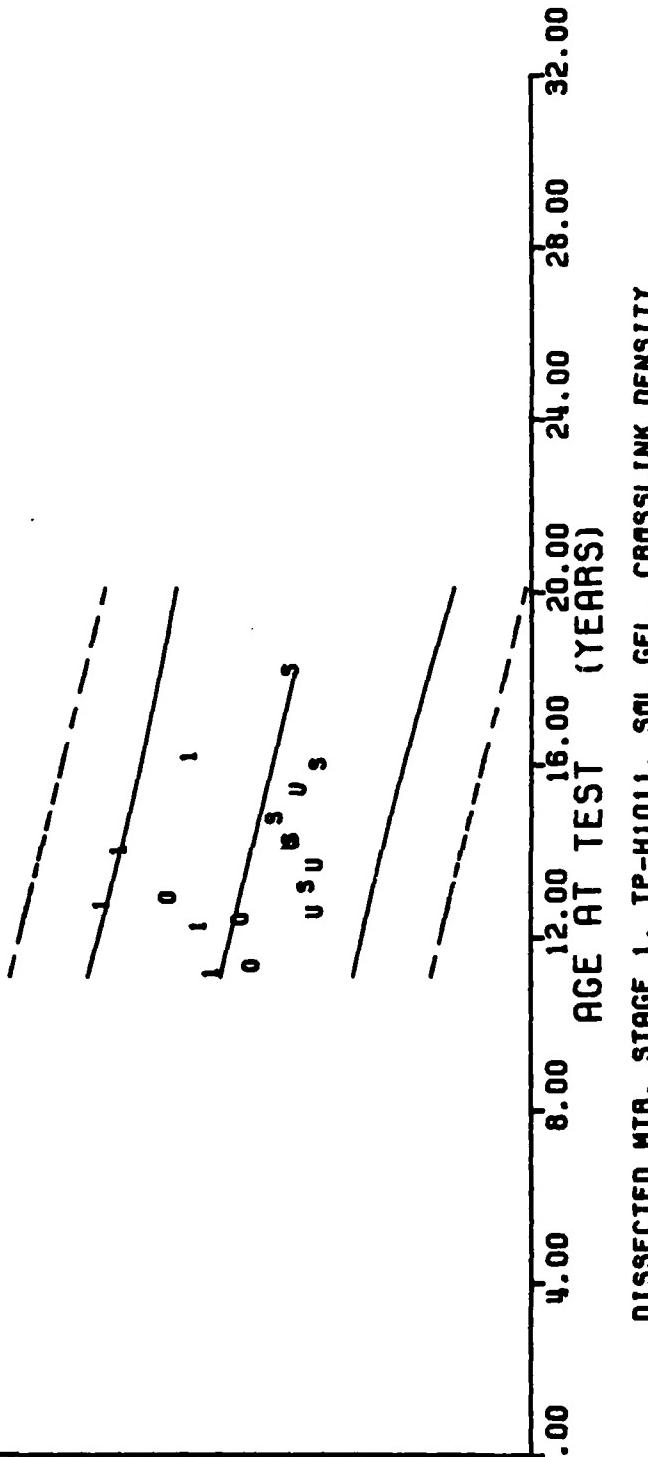


Figure 48

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

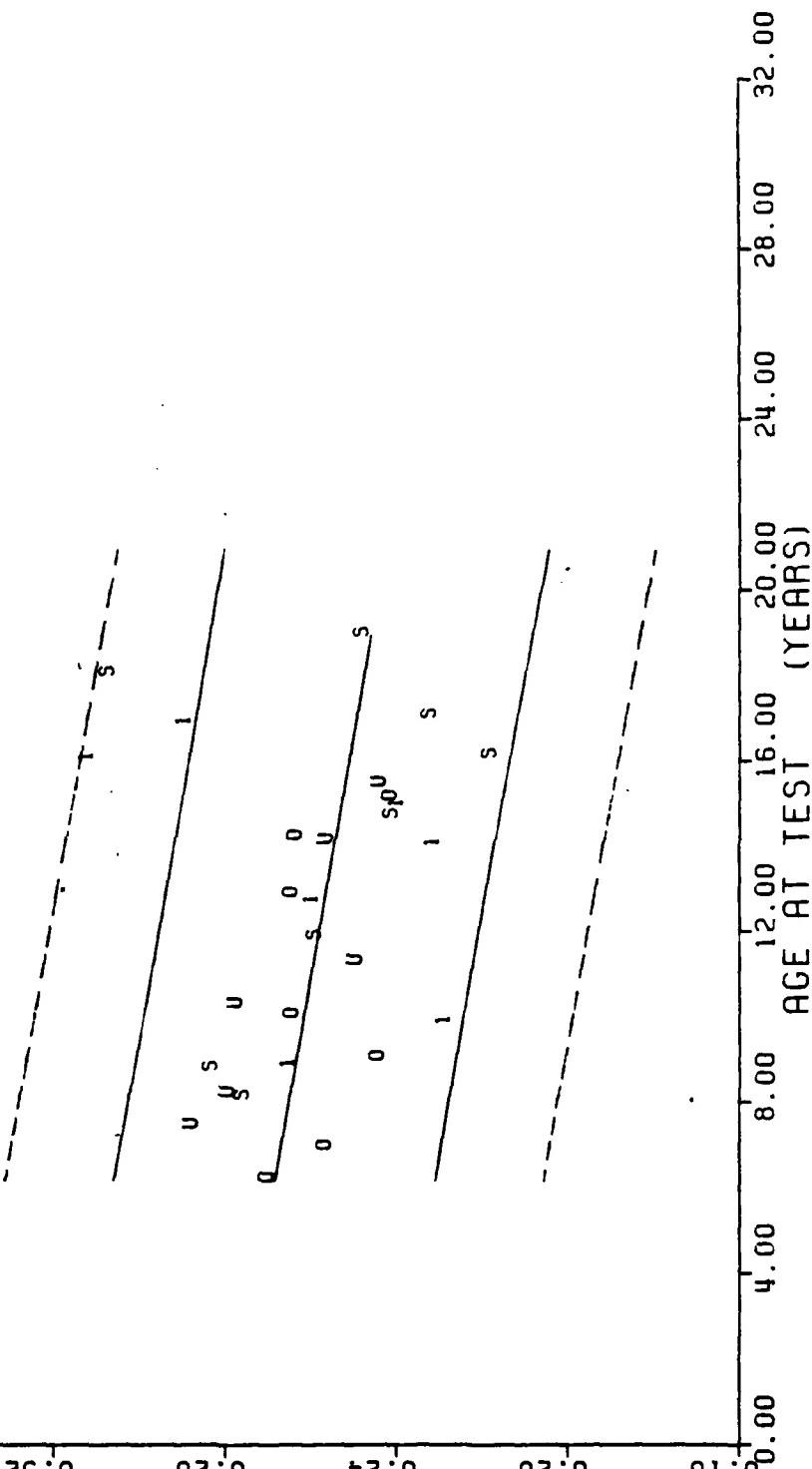
AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
74.0	18	204.0	6
83.0	6	216.0	3
89.0	6	227.0	6
97.0	6		
98.0	6		
105.0	6		
106.0	6		
108.0	5		
118.0	5		
120.0	5		
123.0	5		
135.0	5		
142.0	5		
152.0	6		
154.0	6		
168.0	6		
169.0	6		
170.0	6		
176.0	6		
179.0	6		
181.0	6		
185.0	6		
192.0	6		
193.0	6		
202.0	6		

STAGE 1 DISSECTED MOTORS. BURNING RATE AT 500 PSI INITIAL PRESSURE

This sample size summary is applicable to figure 49

$F = +1.7477424E+01$        $y = i( +2.794402E-01 - 1.4796502E-04) * x$   
 $R = -3.094811E-01$       SIGNIFICANT  
 $t = +4.1806010E+00$       SIGNIFICANT  
 $N = 167$       DEGREES OF FREEDOM = 165  
 STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

UNIT OF MEASURE = IN/SEC  
 PARAMETER = BURNING RATE  
 0.00 0.20 0.24 0.28 0.32 0.36



STAGE 1 DISSECTED MOTORS, BURNING RATE AT 500 PSI INITIAL PRESSURE

Figure 49

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NF SAMPLES	AGE (MONTHS)	NR SAMPLES
74.0	6	176.0	6
83.0	6	179.0	6
89.0	6	181.0	6
97.0	6	185.0	6
98.0	6	192.0	3
105.0	6	193.0	6
106.0	5	202.0	6
108.0	6	204.0	6
116.0	6	216.0	6
120.0	6	227.0	6
123.0			
130.0	6		
135.0	5		
137.0	8		
139.0	6		
142.0	6		
145.0	6		
147.0	5		
152.0	6		
154.0	11		
161.0	5		
162.0	5		
168.0	6		
169.0	11		
170.0	6		

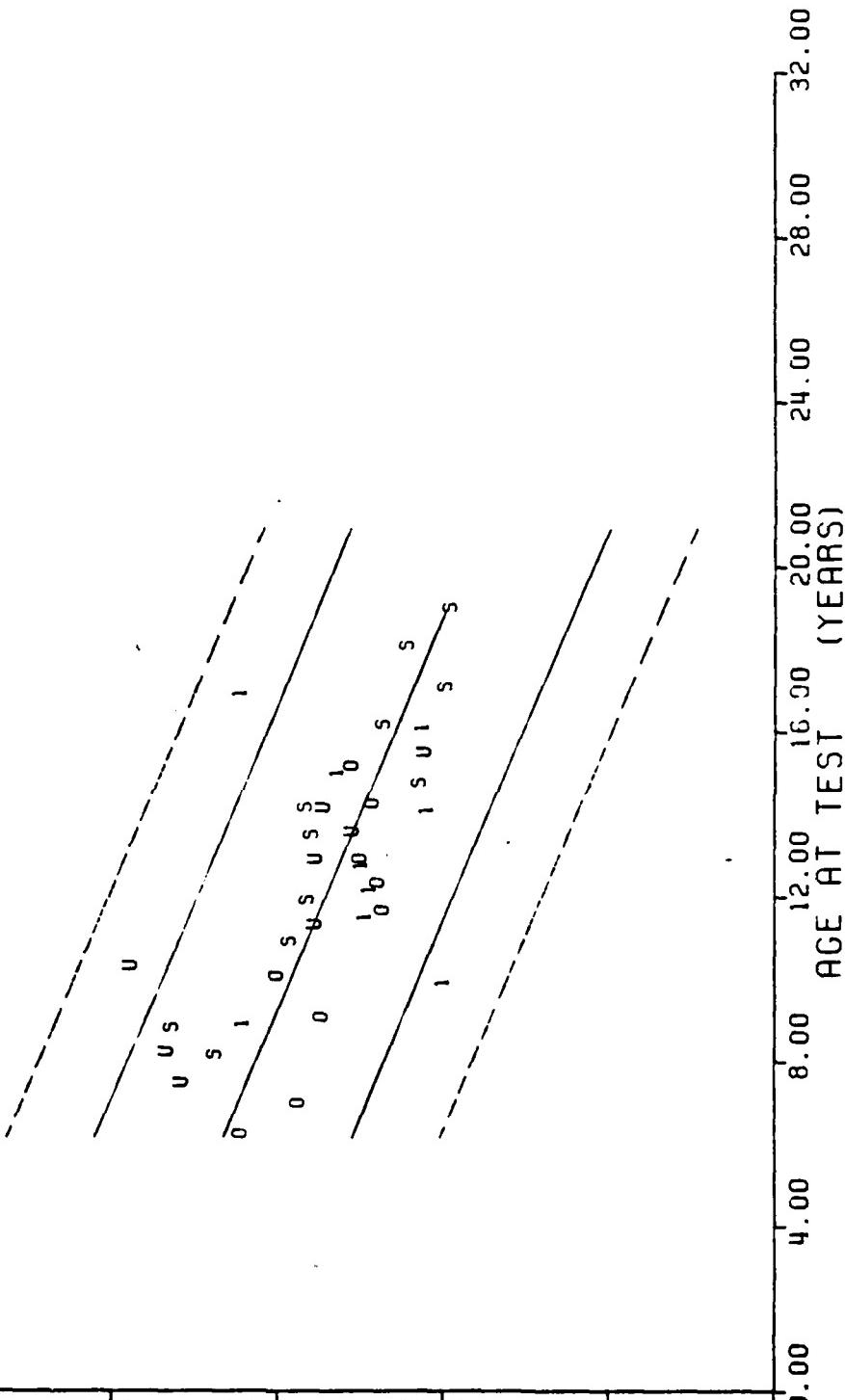
STAGE 1 DISSECTED MOTORS. BURNING RATE AT 100C PSI INITIAL PRESSURE

This sample size summary is applicable to figure 50

$F = +1.1926894E+02$        $\gamma = (( +3.5895544E-01 ) + (-3.4983541E-04) * X)$   
 $R = -6.1024786E-01$       SIGNIFICANCE OF F = SIGNIFICANT  
 $L = +1.0921032E+01$       SIGNIFICANCE OF R = SIGNIFICANT  
 $N = 203$       SIGNIFICANCE OF L = SIGNIFICANT  
DEGREES OF FREEDOM = 201

STORAGE CONDITIONS = AMB TEMP/RH      TEST CONDITIONS = AMB TEMP/RH

$P\text{RAMETER} = \text{BURNING RATE}$   
UNIT OF MEASURE = INCHES/SEC  
0.24    0.28    0.32    0.36    0.40



STAGE 1 DISSECTED MOTORS. BURNING RATE AT 1000 PSI INITIAL PRESSURE

Figure 50

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	NR SAMPLES	AGE (MONTHS)	NR SAMPLES
74.0	3	216.0	3
76.0	3	226.0	3
83.0	3		
91.0	3		
98.0	6		
105.0	3		
108.0	1		
110.0	1		
125.0	1		
132.0	1		
136.0	1		
138.0	1		
152.0	1		
153.0	1		
154.0	1		
160.0	3		
167.0	3		
169.0	6		
175.0	3		
176.0	3		
184.0	3		
191.0	3		
193.0	3		
200.0	3		
202.0	3		

STAGE 1 DISSECTED MOTORS, HEAT OF EXPLOSION

This sample size summary is applicable to figure 51

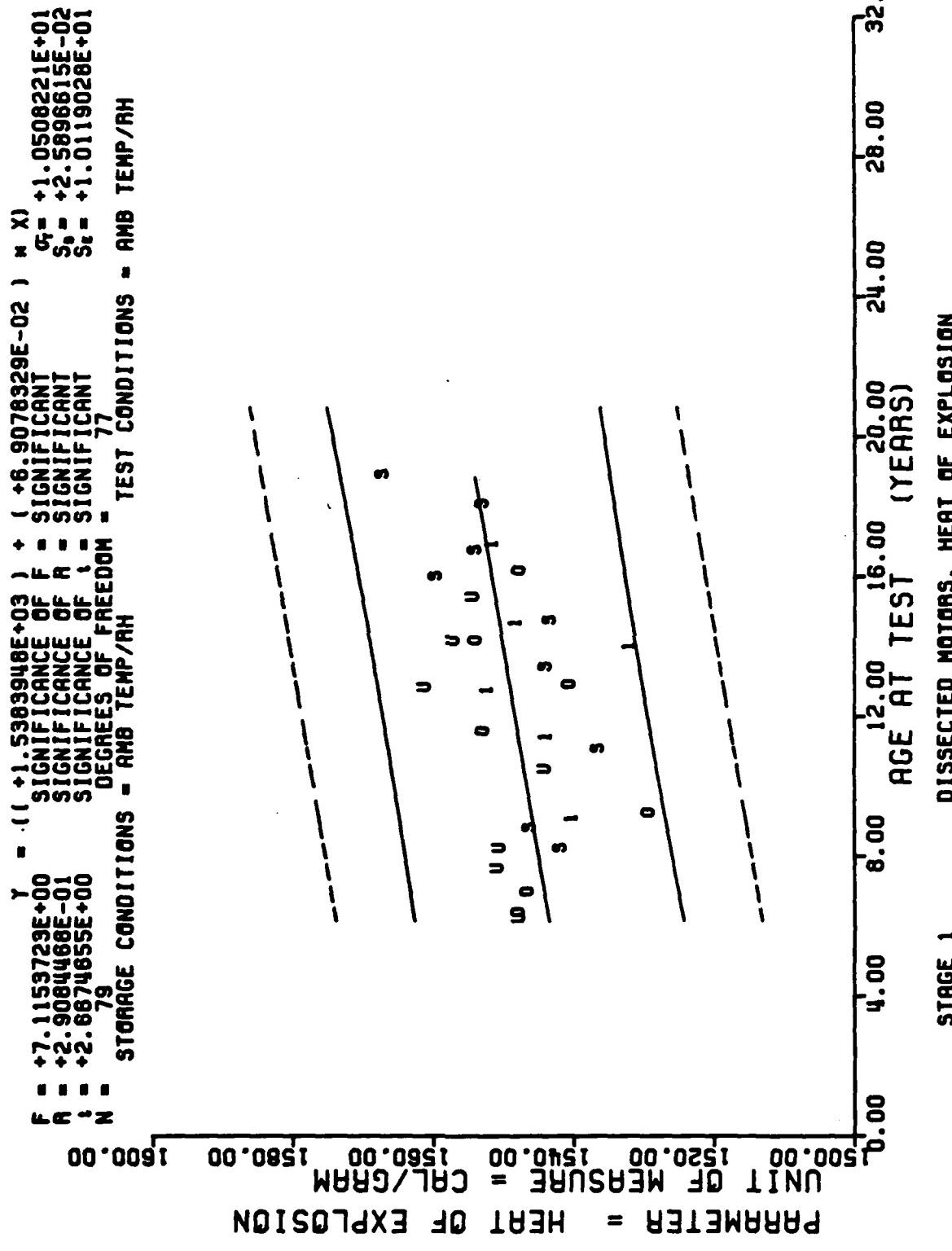


Figure 51

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE  
(MONTHS)    NR  
SAMPLES

73.0	4
75.0	3
83.0	2
90.0	3
98.0	9
105.0	5
114.0	3
116.0	3
133.0	3
135.0	3
137.0	3
140.0	3
152.0	2
154.0	2
160.0	3
167.0	3
169.0	9
176.0	2
177.0	3
179.0	3
184.0	5
192.0	3
201.0	0

STAGE 1    DISSECTED MOTORS, DIA. EIGHTEEN 1, TWELVE C RISE/MINUTE

This sample size summary is applicable to figures 52 and 53

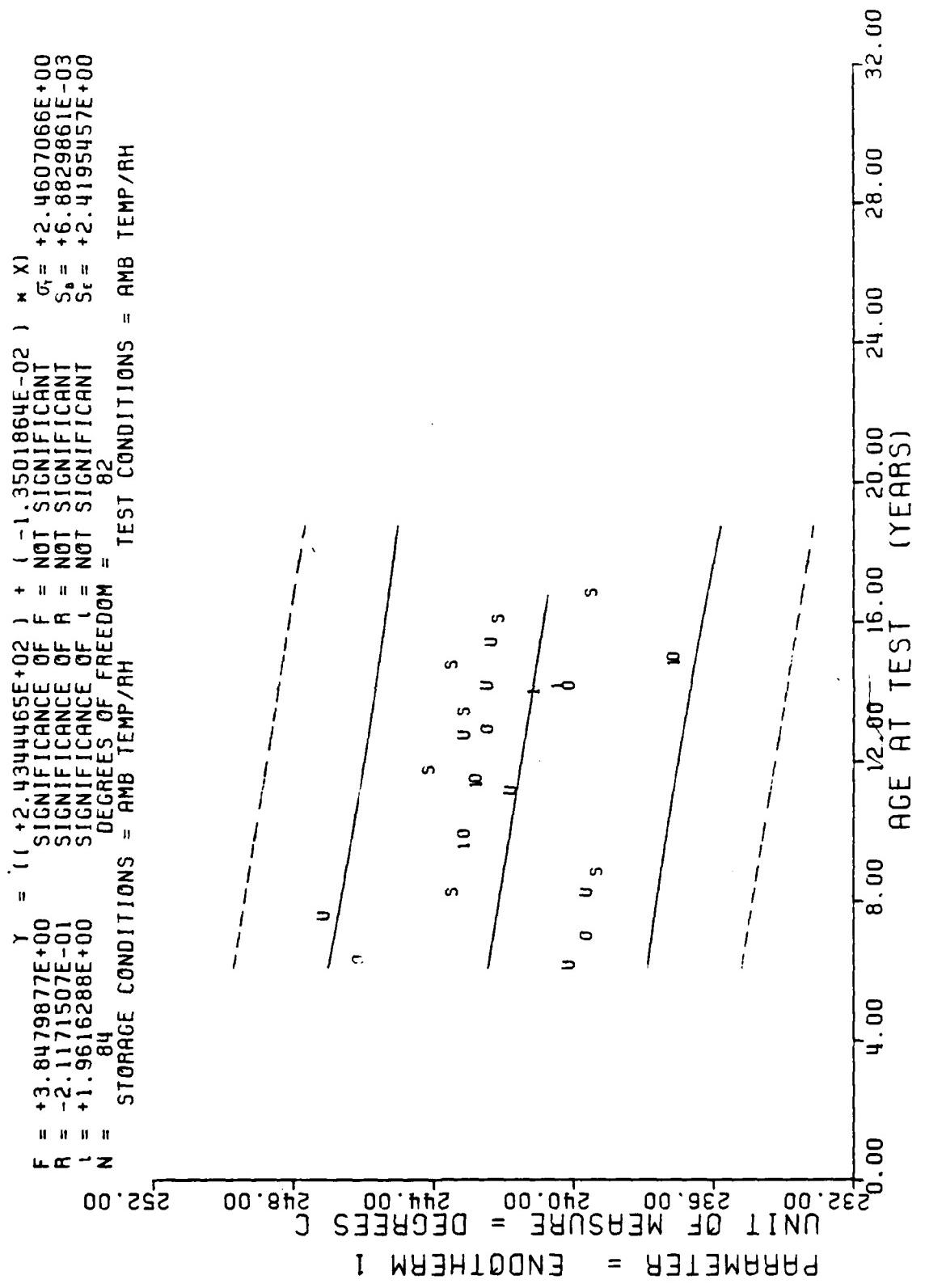


Figure 52

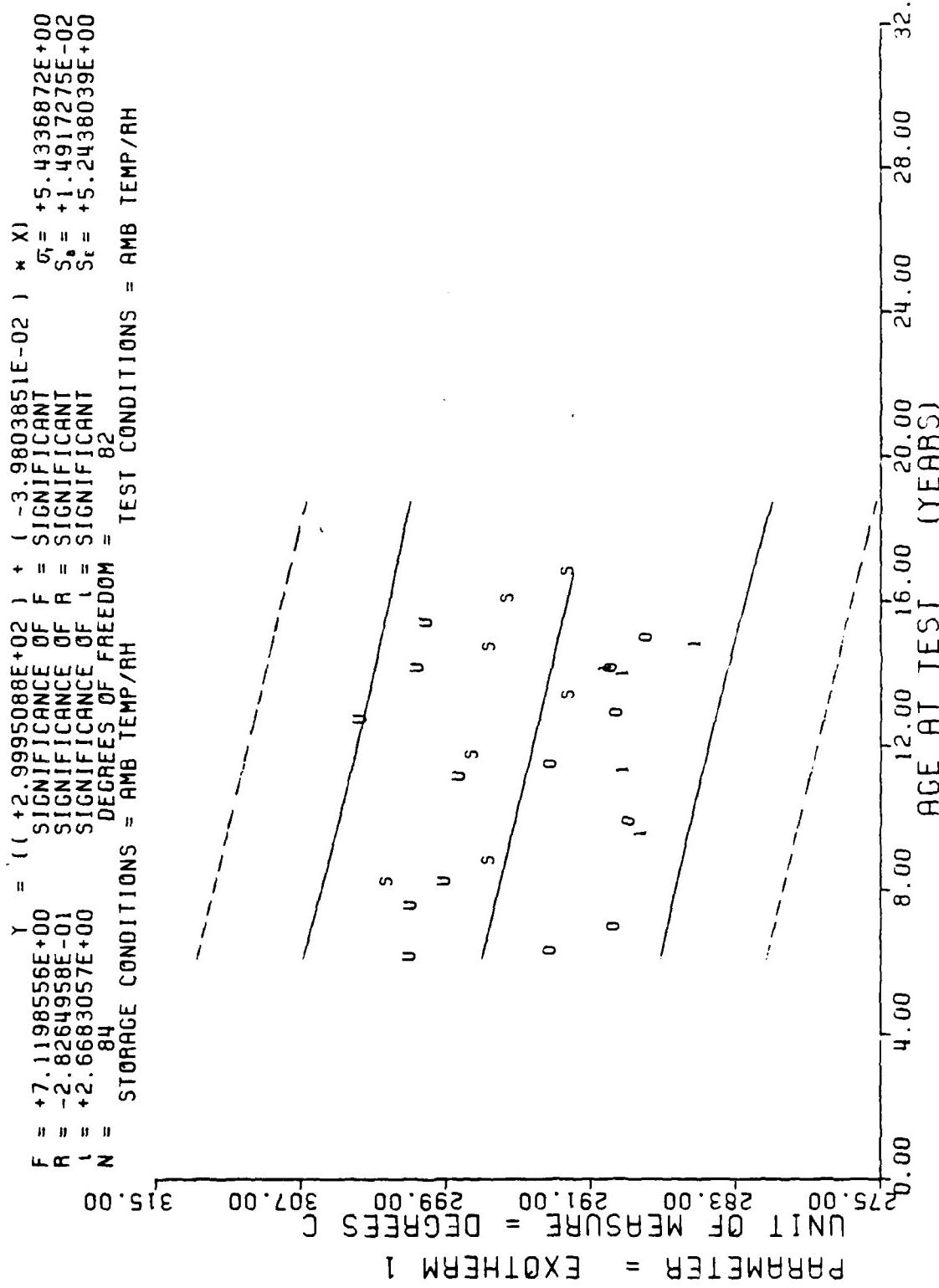


Figure 53

\*\*\* SAMPLE SIZE SUMMARY \*\*\*

AGE (MONTHS)	N <sub>F</sub> SAMPLES
73.0	4
75.0	3 2
83.0	2
90.0	2
98.0	9
105.0	5 2
114.0	3
133.0	2
135.0	3
140.0	3 2
152.0	1
154.0	2
167.0	6
169.0	2
176.0	2
177.0	3
179.0	2
184.0	5
192.0	2
201.0	3

STAGE 1 DISSECTED MOTES. DATA IGNITION TEMP, 12 CEG C DISE/MINUTE

This sample size summary is applicable to figure 54

AD-A098 409      OGDEN AIR LOGISTICS CENTER HILL AFB UT PROPELLANT AN--ETC F/G 21/9.2  
SURVEILLANCE REPORT, STAGE I DISSECTED MOTORS, PHASE XII. PROPE--ETC(U)  
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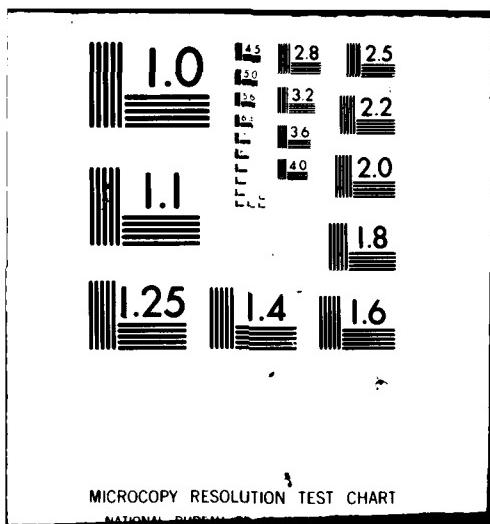
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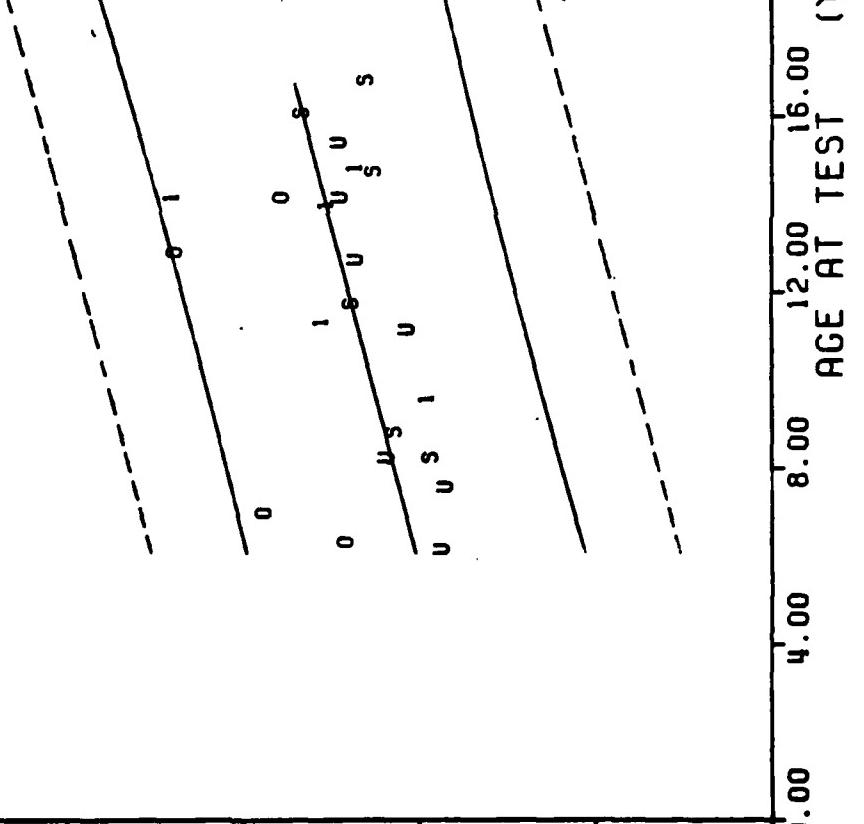


END  
DATE  
JAN 81  
5-81  
DTIC



$\gamma = (( +3.5261042E+02 ) + ( +1.0680296E-01 ) * X) * X$   
 $F = +1.2835442E+01$  SIGNIFICANT  
 $R = +4.1140475E-01$  SIGNIFICANT  
 $I = +3.5826585E+00$  SIGNIFICANT  
 $N = 65$  DEGREES OF FREEDOM = 63  
 STORAGE CONDITIONS = AMB TEMP/RH TEST CONDITIONS = AMB TEMP/RH

UNIT OF MEASURE = DEGREES C  
 PARAMETER = IGNITION TEMP



STAGE 1 DISSECTED MOTORS, DTA IGNITION TEMP, 12 DEG C RISE/MINUTE

Figure 54

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER MAKPH Report Nr 452(81)	2. GOVT ACCESSION NO. HD-A098409	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Surveillance Report, Stage I Dissected Motors, Phase XII	5. TYPE OF REPORT & PERIOD COVERED Test Results - Semi annual	
7. AUTHOR(s) John A. Thompson	6. PERFORMING ORG. REPORT NUMBER	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Propellant Lab Section Directorate of Maintenance Hill AFB, UT 84056	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS Service Engineering Division Directorate of Materiel Management Hill AFB, UT 84056	12. REPORT DATE January 1981	
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18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  Minuteman Solid Propellant		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  Testing was performed to determine the useful shelf/service life for LGM-30 Stage I Rocket Motors. A three year storage program for propellant and components was started in May 1961. This program was then extended to a ten year study and later continued indefinitely to assure that a deterioration in motor physical characteristics could be detected in time to take some corrective actions before the weapon system performance deteriorated below an acceptable level.		

This report covers only propellant data and limited case bond data. The malfunction of an environmental chamber destroyed component samples that had originally been part of this testing program (and the inadvertent burning of some motors during dissection reduced the material available for testing). Planned dissection of selected motors in the future will provide samples for continued component testing. Test specimens for this reporting period were obtained from motors STM-012, 0012099, and 012199. Up-7775 block propellant was not tested since the propellant has been used up.

Separate analyses were made on the respective motors and block propellant for the second time in this report and are shown in the regressions. The plotting symbols for each motor and block propellant are listed in the statistical analyses section.

The data from this test period was combined with data from previous testing and entered into the GO8A computer for storage, analysis, and regression analysis. From the statistical analysis of all data tested to date, significant degradation of the propellant does not appear likely for at least two years past the oldest data point.

Future testing will be conducted on dissected motors.

